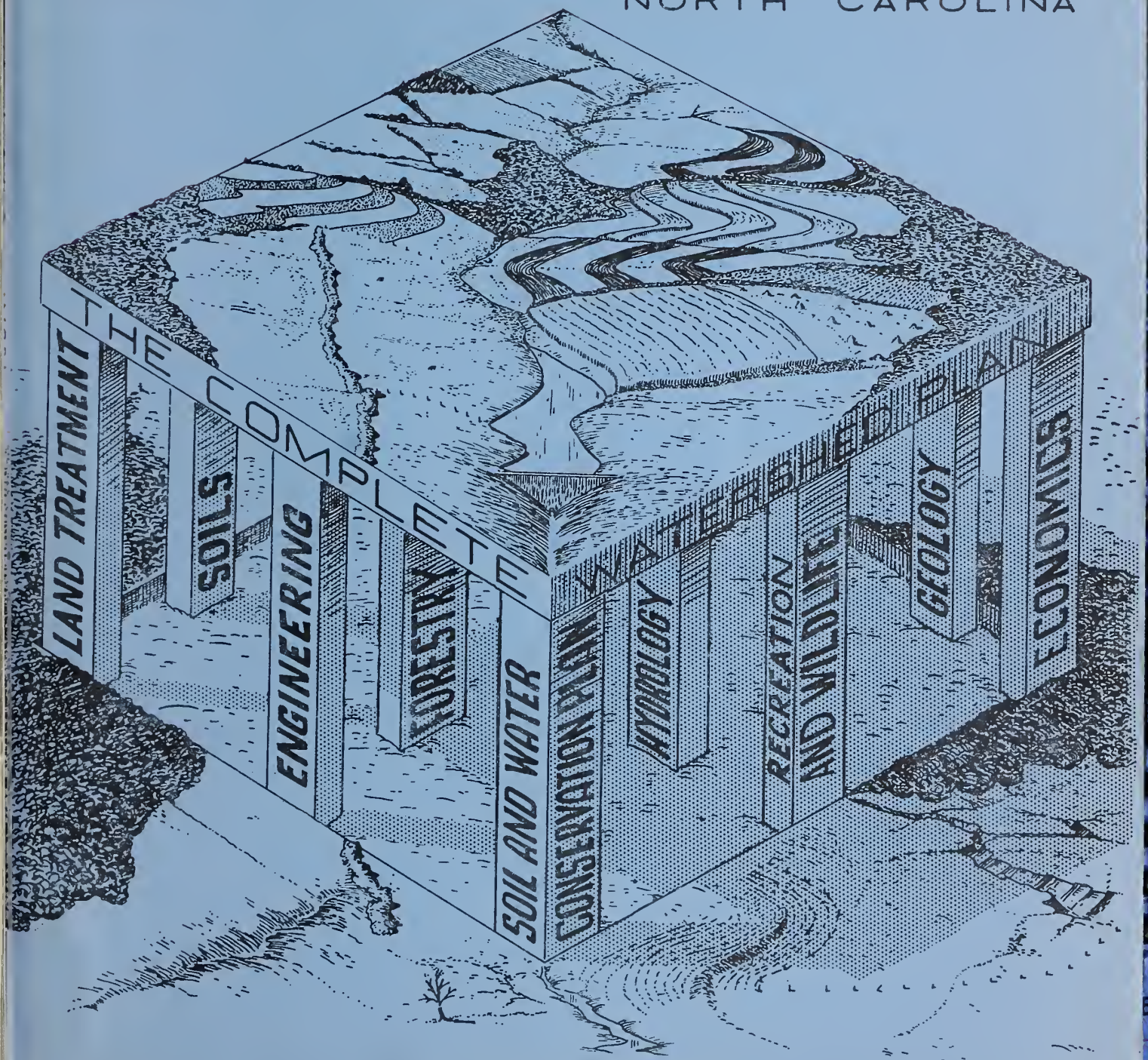
ABTREE CREEK Watershed Work Plan

WAKE AND DURHAM COUNTIES
NORTH CAROLINA



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SOIL CONSERVATION SERVICE

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WATERSHED WORK PLAN

CRABTREE CREEK WATERSHED

Durham and Wake Counties, North Carolina

Prepared Under the Authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress, 68 Stat. 666), as amended.

Prepared by: Neuse River Soil and Water Conservation District

County Commissioners of Wake

City of Raleigh

Crabtree Creek Watershed Improvement District

With assistance by:

U. S. Department of Agriculture, Soil Conservation Service

U. S. Department of Agriculture, Forest Service

March 1964

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SUMMARY OF PLAN

The watershed, consisting of 90,750 acres, is located in Durham and Wake Counties, North Carolina. It is sponsored by the Neuse River Soil and Water Conservation District, the County Commissioners of Wake, the City of Raleigh, and the Crabtree Creek Watershed Improvement District. Soils are of Triassic origin in the upper portion of the watershed and of acid crystalline origin in the lower portion.

The population is 69,500 with 80 percent living within the city of Raleigh. Approximately 60 percent of the watershed is in woodland, 17 percent in cultivation and 23 percent urban, industrial and miscellaneous. One hundred and eighty-nine basic soil and water conservation plans have been developed by landowners and operators.

Floodwater damages are extremely variable. Damages to agriculture occur in the headwaters from flooding on 756 acres. In the central portion there is very little flood plain and the area is practically all wooded. The lower portion of the watershed contains 1,781 acres subject to inundation from a 100-year frequency storm. There are presently 189 homes and 30 business or industrial establishments in this area of flood plain. All of the area has been zoned for urban or industrial development. A major storm would endanger the lives of 400 to 3,000 persons, depending on the length of time before it occurs.

The efforts of the North Carolina Forest Service, the U. S. Forest Service, the North Carolina Extension Service, the Agricultural Stabilization and Conservation Service, the U. S. Army, Corps of Engineers, and others will be coordinated to develop the potentials of the watershed. The U. S. Army, Corps of Engineers, has proposed a dam on the Neuse River above the confluence of Crabtree Creek which will benefit the Crabtree Creek Watershed.

The objectives of the sponsoring local organizations are to reduce floodwater and sediment damages on agricultural flood plains and to provide 100-year storm frequency protection to the urban and industrial zoned flood plain in and adjacent to the city of Raleigh by utilizing structural works of improvement, supported by land treatment on the upland. To accomplish

the stated objectives, works of improvement to be installed include land treatment measures for protection of the land and structural measures for flood prevention.

Land treatment measures consist of vegetative and engineering measures to reduce erosion and runoff and improve soil structures. These measures are estimated to cost $728,310 of which non-P.L. 566 funds will pay $562,620 and P.L. 566 funds will pay $165,690. Structural measures consist of 15 floodwater retarding structures, 79,700 feet of stream channel improvement, 1,260 feet of streambank protection and 51,423 feet of clearing and snagging of channels.

Structural measures are estimated to cost $4,654,810 of which $3,858,240 will be P.L. 566 funds and $796,570 (value of land, easements and rights-of way, and administration of contracts), will be borne by the sponsoring local organizations.

The project will reduce the agricultural area flooded by a storm of the magnitude of the one which occurred in May 1957 from 612 acres to 217 acres. One hundred year protection will be provided to 1,372 acres of urban and industrial areas and 158 additional acres will flood at very infrequent intervals.

The project installation period will be eight years with land treatment starting the first year and structural measures commencing the third project year. Land treatment measures will be installed and maintained by landowners and operators with whatever assistance is available under going programs. Technical assistance will be increased with P.L. 566 funds. Construction costs and installation services will be provided from funds appropriated under P.L. 566. Land, easements and rights-of-way, and the administering of contracts will be provided by the sponsoring local organizations. These measures will be operated and maintained by the Crabtree Creek Watershed Improvement District.

Installation of works of improvement will result in an estimated average annual benefit of $615,280. Average annual costs, including operation and maintenance, is estimated to be $220,253. The project will yield a 2.8 to 1.0 benefit-cost ratio.

DESCRIPTION OF THE WATERSHED

Physical Data

The Crabtree Creek Watershed, consisting of 90,750 acres, is located in Durham and Wake Counties, North Carolina. The stream has its origin

east of a low ridge extending north and south, approximately four miles west of the Raleigh-Durham Airport. It flows easterly some 20 miles to its confluence with the Neuse River.

The watershed is divided into two distinct areas by topography and soils. Broad expanses of gently rolling upland with wide flat flood plains occupy the upper third of the watershed. Soils in this area are derived from Triassic materials and have sandy loam topsoils where uneroded and very plastic clay subsoils. They are mostly in the White Store and Creedmoor series. In the lower two-thirds of the area the topography is more broken with gently rolling to rolling upland, steep breaks adjacent to streams and irregular width flood plains. Soils have formed from weathered acid crystalline rocks and have sandy loam topsoils where uneroded, with friable subsoils. They are classified in the Cecil, Appling, and other series associated with them.

Approximately 60 percent of the watershed is presently in woods, 17 percent in cultivated land and 23 percent in urban, miscellaneous and idle. Cover conditions are considered to be fair.

Present use of water from the watershed is limited to agriculture. Water for irrigation, farm ponds and livestock use comes from surface streams while water for family use is obtained from deep wells.

Temperatures vary from a normal high of 95 degrees Fahrenheit in summer to a normal low of 7 degrees Fahrenheit in winter, with extremes of 105 degrees Fahrenheit to 2 degrees Fahrenheit recorded. There are normally 41 days when the high is greater than 90 degrees Fahrenheit and 51 days when the low is 32 degrees Fahrenheit or lower. The growing season is 207 days extending from March 24 to November 14. The average annual rainfall is 46.35 inches.

Economic Data

The major cash crop of the watershed is tobacco. Corn and small grains are grown for domestic use. Livestock is produced by a limited number of farmers in rather small amounts. Present land use within the watershed consists of 14 percent cropland, three percent pasture, hay and wildlife, nine percent idle and miscellaneous, 14 percent urban, and 60 percent woodland. Of the land in woodland, ten percent is in State parks.

There are 623 farms within the watershed. The average size farm is 71 acres and the value per farm is $11,284, according to the 1954 U. S. Agricultural Census. Present population of the watershed is estimated to be 69,500. Of this number, 55,000 are within city limits, 2,500 rural agricultural, 5,000 rural non-agricultural, and 7,000 suburban.

The area is served by an excellent net work of roads and railroads. U. S. Highways Nos. 1, 64, 70, 70-A, 401, and State Highways Nos. 50 and 54, plus numerous farm-to-market paved roads serve the area. The Seaboard Air Line Railroad, Southern Railway, and Norfolk Southern Railway have main lines which afford adequate freight service.

Status of Going Soil and Water Conservation Program

One hundred and eighty-nine basic soil and water conservation plans covering 13,131 acres have been developed by landowners in the watershed. The land treatment measures and practices which have been applied to date are shown on Table 1a.

WATERSHED PROBLEMS

Floodwater Damages

Floodwater damages in the Crabtree Creek Watershed are extremely variable by areas. Agricultural damage prevails in the headwaters. In the central portion, the stream passes through a gorge section where very little damages occur. The lower portion of the stream flows through an urban, suburban and industrial section of the city of Raleigh.

Agricultural damages from flooding affect 756 acres, which at one time were used for crop production. Most of this area is extremely flat and floods two or three times a year with at least one flood occurring during the growing season. Present values of agricultural flood plain lands are directly proportional to the frequency of floodwater damages. Land where a crop can be produced and harvested two out of three years is valued at $400 - $500 per acre. As the frequency and severity of flooding increases,the value drops to as low as $100 per acre.

Very little flood damages occur in the central portion of the watershed. The small amount of flood plain that exists is practically all in woodland and used for nature trails and similar recreational facilities. A large portion of this area is in the Umstead and Reedy Creek State Parks.

The lower portion of the watershed is in the northern section of the city of Raleigh and a 100-year frequency storm would inundate 1,781 acres. Floodwater damages to this area can best be illustrated by a storm which occurred in May 1957. Hydrologic determinations indicate that this storm was of 6.7-year frequency; however, it is the largest on record since the flood plain has been in urban use. This storm

flooded 50 homes, the Farmers Market, and other industrial developments. Floodwater damage from this one storm amounted to more than $100,000 in this portion of the watershed.

The entire lower portion of the watershed has been zoned for urbanization and industrial development. Presently there are 189 homes that would be damaged by a once-in-a-century storm. Numerous industrial developments would be damaged. The value of the land in this portion of the flood plain varies from $500 to $10,000 per acre -- depending on the frequency and depth of flooding. A major storm would endanger the lives of 400 to 3,000 people -- depending on the length of time before it occurs. Small floods are a nuisance in that they create a mosquito problem. Larger storms are the limiting factor in the development of this large block of flood plain land.

Sediment Damage

Damage to crop and pasture land from infertile deposition is insignificant in the watershed. A very few small damaged areas occur in the upper reaches. These are mostly above floodwater retarding structures and will not benefit from structural works of improvement.

Some tributary channels have been filled with sediment and this has resulted in the swamping of flood plain land. However, progressive swamping has ceased. Therefore, benefits accruing from this source will result from restoring the land to its former state of use.

There is no land damage from flood plain scour or channel erosion.

Erosion Damage

Approximately 65 percent of the cultivated land within the watershed is located in the upper third. This area is composed of soils of Triassic origin and exceedingly susceptible to erosion. At some time in the past gully erosion was a serious problem; however, presently these gullied areas have been revegetated and today the major problem is sheet erosion. Crop controls and a shift of population from agriculture to industry is relieving the load of agricultural lands to the extent that soil and water conservation measures can control this sheet erosion problem. It is estimated that sheet erosion has reduced the potential yields per acre by 40 percent.

Problems Relating to Watershed Management

The town of Cary releases the effluent from the sewage disposal plant into the headwaters of Crabtree Creek. In addition to this source, there are numerous suburban development areas on soil types which are

not suited to septic tanks and disposal fields. These areas will, in the future, require group facilities for sewage disposal. As these facilities are established, the need for pollution abatement will materially increase where now it is of minor importance.

PROJECTS OF OTHER AGENCIES

The Research Triangle Regional Planning Commission is developing long term plans for a portion of Wake, Durham and Orange Counties. A part of the area on which they are developing plans is within the watershed. This plan and the Triangle Plan have been coordinated insofar as feasible at this time. The Triangle is dependent upon funds appropriated by the three counties, the cities of Chapel Hill, Durham and Raleigh to install their plans; therefore, no firm commitments can be made by the Triangle.

The U. S. Army, Corps of Engineers, are investigating a flood control dam on the Neuse River, of which Crabtree Creek is a tributary. The dam, however, is above the confluence of the two waterways. The Crabtree Creek Watershed will not affect the dam on the Neuse River; however, the dam on the Neuse River will reduce the backwater flooding on Crabtree Creek. When this dam is constructed, flood plain lands of Crabtree Creek can then be utilized to the confluence with the Neuse River.

The North Carolina Division of Forestry, in cooperation with the U. S. Forest Service, is providing forest fire protection in the watershed. This protection is provided under Section 2 of the Clarke-McNary Program.

Technical forest management assistance is furnished by the North Carolina Division of Forestry, in cooperation with the U. S. Forest Service. This service is a part of the Cooperative Forest Management Act.

BASIS OF PROJECT FORMULATION

Project formulation considerations were based on the objectives agreed upon with the sponsoring local organizations. Inasmuch as there are three separate and distinct problem areas within the watershed, the objectives necessarily were tailored to meet the needs of these areas. There are as follows:

1. In the upper third of the watershed, the land is used for agricultural purposes. For this area the objectives agreed upon are (a) to protect the upland from erosion

by the application of soil and water conservation practices and measures, and (b) reduce the frequency and area of flood plain inundated by storm runoff.

2. The central portion of the watershed is becoming urbanized with agriculture rapidly being displaced. Flood plains are narrow and this portion of the watershed presents no special problems. The stated objectives are to utilize this area to the maximum for homes.

3. The flooding problems in the lower third of the watershed overshadow the problems of the other portions. About 1940, Raleigh experienced a tremendous growth which has expanded the population and city limits. Approximately 1,781 acres of land within or adjacent to the city limits are subject to inundation from a 100-year storm.

   Subdivision and industrial plants have already been planned or established on most of this area. One hundred and fifty or more homes and several industrial plants would be damaged by the recurrence of the 1957 flood which was approximately a 6.7-year frequency storm. One hundred year storm frequency protection from flooding was considered as the project objective and a "must" for this portion of the watershed, by the sponsoring local organizations and all others concerned.

Land treatment measures included in this plan are those which will (a) be effective in reducing erosion damage to existing cropland, (b) reduce runoff and sediment production that would adversely affect the operation, maintenance and the life of proposed structural works of improvement, and (c) would increase the efficiency of land use on existing farm land.

Structural works of improvement were selected to meet the objectives of the sponsoring local organizations consistent with physical characteristics of the watershed, Service policies and engineering criteria. The maximum utilization of floodwater retarding structures plus necessary channel enlargement and improvement required to meet the project objectives were discussed with and approved by the sponsoring local organizations after alternative systems had been considered and evaluated.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

Land treatment measures included in this plan were considered as the basic element in formulating the watershed project. They are necessary and justified for the (1) conservation, development and improvement of agricultural tracts of land, and (2) assurance of the continuing effect of proposed structural works of improvement. These measures will be planned and applied in cooperation with the Neuse River Soil and Water Conservation District. Technical assistance for planning and installation will be provided by the Neuse River Soil and Water Conservation District. The North Carolina Division of Forestry, in cooperation with the U. S. Forest Service, will provide technical assistance for planning and installing the forestry measures.

a. Water Disposal

Land smoothing, terraces, and diversions with grassed waterways and stripcropping will reduce runoff, erosion and sediment production from sloping cropland. Farm ponds will be constructed to provide a reservoir of water for farm use and to permit adequate distribution of grazing on pasture lands. Tile will be installed where needed to drain pockets of wet land, thereby permitting the installation of other soil and water conservation practices.

b. Vegetative Control

Perennial hay will be established on suitable upland to increase infiltration rates, reduce runoff and materially reduce sheet erosion.

Pasture will be planted on idle land and eroded cropland. Existing pasture with poor cover conditions will be renovated. These land use adjustments and improved cover conditions will reduce runoff and erosion from the affected areas and will assure their sustained agricultural use.

Planned conservation cropping systems which include cover crops, grasses and legumes in rotation, and crop residue use will be installed to protect cropland from erosion, reduce runoff and increase soil fertility.

Vegetation which protects field borders and produces wildlife food and cover will be planted in suitable areas. These plantings will improve wildlife habitat, make effective

use of areas not suitable for other uses, and reduce erosion.

c. Forestry

Hydrologic Stand Improvement: Hydrologic stand improvement is needed on 2,450 acres of woodland. This will improve the capability of the soil to take in rainfall at the surface. The measure will consist of the selection of areas where poor quality tree species will be chemically treated to favor the better species.

Harvest and improvement operations will include the selection and marking of trees for cutting, the proper design and location of logging roads, skid trails and haul roads. The more vigorous and better soil building tree species will be left in all forest operations.

Improvement of the protective canopy of trees above the soil surface and the maintenance of a thick porous layer of organic material at the soil surface will achieve the desired result. Measures needed to produce the desired improvement in the hydrologic condition of the forest and its soil are: (1) the release of vigorous, young growing stock from competing vegetation, (2) the modification of harvesting methods and cutting cycles, and (3) the exclusion of domestic grazing from wooded areas.

It is important that a sufficient number of favorable humus building species be left in all operations to insure the development of well aggregated forest soils. These soils will then be able to perform their normal function of rapidly infiltrating storm rainfall and retarding flood producing runoff.

Tree Planting: Trees will be planted on 1,896 acres of idle or open land. The sites selected are not critical sources of sediment or storm runoff. The ability of these areas to develop and increase their water intake and storage capacities will be improved by planting trees. Loblolly pine is recommended for most of the planting. Other tree species may be used on suitable sites. The cost of carrying out this practice will be entirely from non-P.L. 566 funds.

Cooperative Forest Fire Control: The entire watershed is under organized forest fire protection. There is need for additional forest fire suppression equipment to aid in

reducing the area damaged by wildfire each year. This measure is essential to insure the success of other phases of the watershed forestry program. A forest fire suppression unit consisting of a pick-up truck equipped with a mobile two-way radio, fire suppression tools and a waterpump will be provided to promote more efficient suppression and control of woodland fires.

Purchase and installation costs will be shared equally by the P.L. 566 Program and the North Carolina Division of Forestry. Operation and maintenance will be provided by the North Carolina Division of Forestry under the going forest protection program authorized under Section 2 of the Clark-McNary Act.

Structural Measures

Structural measures to be installed consist of the following:

a. Fifteen floodwater retarding structures will detain or confine the runoff from 99.4 square miles, or 70 percent, of the total area of the watershed.

Ninety-four percent of the area will be controlled at the upper end of the highly developed flood plain area, 90 percent at U. S. Highway No. 70, 82 percent at U. S. Highway No. 1-A, 81 percent at U. S. Highway No. 401, and 75 percent at U. S. Highway No. 64.

Structures Nos. 1, 2, 3, 5, 7, 18, 20, and 21 are in series with structure No. 23, and structures Nos. 11 and 23 are in series with structure No. 25.

The floodwater detention capacity of the structures is 22,696 acre-feet (Table 3). This amounts to 4.28 inches of runoff from the drainage areas of these structures and 3.00 inches of runoff from the drainage areas of the entire watershed. All structures were designed to control runoff from a 100-year frequency storm. Structures are also designed to intercept and store 5,746 acre-feet of sediment, which is the sediment production from the area above structures for 100 years. One-half of the sediment production will be stored in the sediment pool area and the remainder in the detention pool area (Table 3), except for structure No. 25 which has no submerged sediment pool.

Detained floodwater will be temporarily stored in detention pools of the structures and released automatically through the principal spillway (conduits) at a predetermined rate. The dewatering time of the floodwater detention pools will

range from 47-hours to 14.8-days. These structures are earth fills and will have vegetated earth emergency spillways.

Approximately 478 acres of flood plain and 204 acres of upland will be within the sediment pools of the structures and an additional 1,479 acres of flood plain and 1,100 acres of upland will be inundated temporarily by the detention pools.

See Tables 1, 2, 3, and structure location map for locations, quantities, costs, and design features.

b. Stream channel improvement will be installed on 79,700 feet of main streams and laterals in the highly developed flood plain area in and adjacent to the city of Raleigh. This channel improvement consists of enlargement and realignment and is necessary to provide 100-year storm frequency protection from flooding. Realignment of channels will shorten the length of Crabtree Creek approximately 11,615 feet. See Tables 1, 2, 3A, and structure location map for locations, costs, design data, and quantities.

Side slopes will be 2.5 to 1.0 where banks are disturbed. Spoil and side slopes will be seeded to prevent erosion. Pipe drop inlets will be installed through spoil banks, as necessary, to prevent erosion and to dispose of adjacent surface runoff.

c. A concrete revetment will be constructed on the west side of the channel from the Farmers Market to U. S. Highway No. 401, a distance of 1,260 feet. This revetment is necessary to protect business developments adjacent to the existing channel.

d. In the headwaters reaches of Crabtree Creek and tributaries, clearing and snagging of channels will be performed to reduce "n" values; thereby providing channel capacity equal to or greater than the release rate of the floodwater retarding structures.

Approximately 51,423 feet of this type work will be performed so that agricultural lands can be suitably utilized. Work performed by clearing and snagging will be limited to the removal of overhanging trees and snags and debris from the channel. See Tables 1, 2, 3A, and structure location map for cost, quantities, design data, and locations.

EXPLANATION OF INSTALLATION COSTS

Land Treatment Measures

The total cost of installing these measures is estimated to be $728,310 (Table 1) of which $165,690, or 23 percent, will be provided from P. L. 566 funds and $562,620, or 77 percent, from other funds. The P. L. 566 funds include for accelerated technical assistance $150,240 to be provided by the Soil Conservation Service and $14,000 to be provided by the U. S. Forest Service. The $65,440 to be provided from other funds for technical assistance consists of $55,440 from P.L. 46 funds under the present Soil and Water Conservation District Program, $9,250 from the North Carolina Division of Forestry and $750 from the Cooperative Forest Management Program.

The North Carolina Division of Forestry will also provide $1,450 for installing a forest fire suppression unit. The $495,730 for the remainder of land treatment will be borne by individual landowners and operators concerned, utilizing cost sharing assistance available through the Agricultural Conservation Program and other similar programs of assistance.

Structural Measures

The total installation cost of structural measures is estimated to be $4,654,810 (Table 1). The P.L. 566 funds to be provided for the installation of these measures are estimated to be $3,858,240. The sponsoring local organizations will bear an estimated $796,570 in project costs.

The Crabtree Creek Watershed Improvement District will provide land, easements, and rights-of-way for all structural measures at an estimated value or cost of $786,670 (Table 1). The value of land, easements, and rights-of-way is $773,170.

The easements and rights-of-way also include $2,000 for the relocation of increase in height of one electric transmission line and one home service electric line, $1,500 for the relocation and modification of one underground telephone cable, and $10,000 for relocation and modification of sewer and water lines. Administration of contracts will cost $9,900.

Four public roads will be affected by detention storage in floodwater retarding structures. These roads will not be relocated or modified inasmuch as the frequency and duration of inundation do not exceed present conditions.

Summary of Installation Costs

The total project installation cost is estimated to be $5,383,120 (Table 1). The amount of $4,023,930, or 75 percent, will be paid from P.L. 566 funds and $1,359,190, or 25 percent, will be borne by local or non-Federal funds.

The expected expenditures in accordance with the anticipated schedule of operations are as follows:

Year	P.L. 566 Funds	Other Funds	Total
First	$ 25,000	$ 3,200	$ 28,200
Second	100,000	30,300	130,300
Third	250,000	190,000	440,000
Fourth	1,462,000	376,000	1,838,000
Fifth	1,443,000	394,000	1,837,000
Sixth	623,000	245,400	868,400
Seventh	100,000	106,140	206,140
Eighth	20,930	14,150	35,080
Total	$4,023,930	$1,359,190	$5,383,120

EFFECTS OF WORKS OF IMPROVEMENT

Installation of the project will accomplish the stated objectives of the sponsoring local organizations. The proposed land treatment and structural program will adequately protect 756 acres of agricultural flood plain and 1,372 acres of urban area.

All of the protected agricultural flood plain land is in the headwaters area near Morrisville. This area will be flood free from a five-year frequency storm, and flood damages would be completely eliminated from 45 of the 50 storms in the 20-year evaluation period. There will be a 95 percent reduction in floodwater damages. Damages from the recurrence of the largest storm of record would be reduced 74 percent by installation of the project.

There will be no increase in the acreage of cropland in the watershed. Needed land use adjustments will be made so that land can be used according to its capabilities and treated according to its needs. Two hundred sixty-three acres of flood plain can be restored to its former productivity or used more intensively.

Secondary benefits from a national viewpoint were not considered pertinent to the evaluation. Local secondary benefits will accrue as a result of increases in the sale of agricultural products and increased income to

local processors, business establishments, and others not directly benefited. These local secondary benefits include the transporting, processing, and marketing of those goods and services that produce the primary benefits. The supply of additional materials and services required to make possible the increased net returns which stem from installation of the project, produce secondary benefits.

At present, 176,400 tons of sediment are delivered to the mouth of Crabtree Creek each year. With the program installed, the sediment yield will be reduced to 47,150 tons annually, a reduction of 129,250 tons.

The flood plain in the lower part of the watershed is within or adjacent to the city of Raleigh. As of October 1962, homes and industries valued at 5.7 million dollars had been constructed in the flood plain.

The project will give greater than 100-year protection to 1,372 acres of urban flood plain, which includes all of the developed area. Old channels and swamp areas totaling 158 acres are too low to be given maximum protection. The city will require these areas to be filled to the 100-year protection level before they can be utilized for construction.

Future runoff conditions, as they affect this part of the watershed, are based on a 25-year projection of urban development. Present protection of the flood plain, therefore, is much greater than the 100-year frequency storm.

About 3,000 landowners will receive direct benefits from the project. Thirty thousand people in the watershed will receive some type of benefit. Presently 400 lives are endangered, and this number will probably increase to 3,000 by the time works of improvement are installed. The project will remove this danger.

The 682 acres of lakes or sediment pools will provide facilities for picnicking, swimming, fishing, water skiing, and boating. These recreational facilities are within easy driving distance of twenty-five cities and towns. An urban population of 250,000 and a non-urban population of 150,000 are affected. Recreational benefits were not used for project justification.

The overall economy of the entire watershed will be greatly enhanced by the project.

PROJECT BENEFITS

Estimated total average annual benefits from installation of the structural works of improvement amount to $615,280 (Table 6).

As a result of reducing the annual flooding, the total average annual damages will be decreased from $89,006 to $169 (Table 5). The present urban damages will be eliminated and a reduction from a present loss of 12 percent to .5 percent of the gross value of agricultural products will be accomplished by installation of the project.

Benefits in the amount of $3,439 will accrue to the more intensive use of the 756 acres of well protected agricultural flood plain. Utilization of urban flood plain that now cannot be used due to excessive flooding will yield $481,377 in urban enchancement benefits.

Secondary benefits in the amount of $54,952 will result from increases in income to processors of products, to business establishments in towns and trade areas affected, and to individuals other than the direct identifiable beneficiaries. Secondary benefits from a national viewpoint were not considered pertinent to the economic evaluation.

Land treatment measures will provide flood damage benefits of about $13,325 annually. It is expected that land use changes will be made on uplands so that it will be used according to its capability class. The overall level of productivity of cropland, grassland, and forest land will increase with the higher level of management made possible with the project.

With the project, woodland productivity will increase through managed use, better fire protection, tree planting and stand improvement. The present woodland acreage, 54,703 acres, will be reduced to 35,634 acres. The largest part of the reduction will come from urbanization of woodland areas.

COMPARISON OF BENEFITS AND COSTS

The average annual flood prevention benefits from the structural measures is estimated to be $560,328 for primary benefits and $54,952 for secondary benefits, for a total of $615,280. The average annual cost, including $39,321 for operation and maintenance, is estimated to be $220,253. This gives a primary benefit-cost ratio for the structural measures of 2.5 to 1.0, and an overall benefit-cost ratio of 2.8 to 1.0. An analysis of these benefits and costs is shown in Tables 4 and 6.

PROJECT INSTALLATION

Land Treatment Measures

The land treatment measures as listed on Table 1 will be installed by landowners and operators in accordance with the Neuse River Soil and

Water Conservation District in accordance with provisions of their individual farm conservation plans. The installation period will be eight years. The cost of installing these measures is estimated to be $495,730 and will be borne by individual landowners concerned, with assistance from the Agricultural Conservation Program and other sources.

The North Carolina Division of Forestry in cooperation with the U. S. Forest Service will provide intensive cooperative forest fire control. The North Carolina Division of Forestry will share on a 50-50 basis with P.L. 566 funds $2,900 for the cost of installing additional forest fire suppression unit.

Technical assistance costs necessary for the planning and application of land treatment is estimated to be $229,680 (Table 1). It is anticipated that funds for technical assistance from existing programs will continue during the installation period at the present rate. This amounts to $55,440 from P.L. 46 funds and $10,000 from Cooperative Forest Management Program and North Carolina Division of Forestry funds.

The sum of $164,240 (Table 1) from monies appropriated under authority of P.L. 566, as amended, will be used to increase the amount of technical assistance made available to the landowners during the project installation period. The Soil Conservation Service will receive $150,240 and the U. S. Forest Service will receive $14,000. Foresters trained in watershed management will be assigned to the project by the North Carolina Division of Forestry in cooperation with the U. S. Forest Service. Technical assistance for tree planting and hydrologic stand improvement will require 30 man-months. The forester will schedule his work to most effectively utilize his time. Costs of his services will be shared by the North Carolina Division of Forestry and P.L. 566 funds. The State may not be in position to financially cooperate in the program when the watershed is approved for operation; therefore, costs for the first year of the program may be borne entirely from P.L. 566 funds. Funds for the remaining years will be on a matching basis as for similar programs.

Structural Measures

Structural measures consist of 15 floodwater retarding structures, 79,700 feet of stream channel improvement, 51,423 feet of clearing and snagging, and 1,260 feet of streambank protection. These measures will be installed during an eight-year period.

The Soil Conservation Service will provide construction funds and cost of installation services for all structural works of improvement. The cost of the relocation of the two service electric line poles which

will be affected by structure No. 1 and the adjustment necessary to the electric transmission line tower affected by structure No. 22 will be borne by the Crabtree Creek Watershed Improvement District. The cost of these two modifications is estimated to be $2,000. This work will be accomplished by the Carolina Power and Light Company.

The detention pools of floodwater retarding structures Nos. 5, 20 and 25 will inundate public roads with the occurrence of storms of 25-year or greater frequency. The North Carolina State Highway Commission has determined that the frequency and duration does not justify modification or relocation of these roads. Structure No. 25 will temporarily inundate approximately 300 acres of Umstead and Reedy Creek State Parks. It has been determined that the depth and frequency of flooding of this park area will not be as great with this and the other 14 floodwater retarding structures in place as it is under present conditions. The North Carolina State Park Service considers that no damage will be done to the park areas.

Approximately 1,470 feet of telephone cables will be within the sediment and detention pool areas of floodwater retarding structure No. 13. This cable will be relocated, replaced with submarine cable or adapted at the discretion of the American Telephone and Telegraph Company.

The Crabtree Creek Watershed Improvement District will secure the 3,262 acres of easements and rights-of-way required for the construction of these floodwater retarding structures.

The stream channel improvement in and adjacent to the city of Raleigh will affect numerous sewer and water lines. These modifications and relocations will be made by the city of Raleigh. Most of these changes will be made as a part of their planned modernization program.

Land, easements and rights-of-way covering 471 acres of permanent easements and 195 additional acres of temporary easements will be secured by the Crabtree Creek Watershed Improvement District for works of improvement on channels.

Streambank protection will be done in connection with channel improvement and will not require any special easements or rights-of-way.

Clearing and snagging on 51,423 feet of headwater and tributary channels will be accomplished in the areas where agricultural use of the flood plain predominates.

The Crabtree Creek Watershed Improvement District will install all structural works of improvement by contract. Cost of letting and administering contracts is estimated to be $9,900 and will be borne by the Crabtree Creek Watershed Improvement District.

As this project is one construction unit, all land, easements and rights-of-way will be secured prior to the letting of contracts for structural works of improvement. Legal authority with power of eminent domain, necessary funds in hand, and an agreement to use such authority and funds may be substituted for easements where easements are not necessary for immediate construction.

FINANCING PROJECT INSTALLATION

Land Treatment Measures

The cost of land treatment measures will be borne by landowners or operators on whose farms these measures are planned, with cost-sharing under the Agricultural Conservation Program and other similar programs. Technical assistance under going programs will be continued at its present rate. Technical assistance for acceleration will be provided from P.L. 566 funds.

Structural Measures

Construction costs and installation services will be provided from funds appropriated under P.L. 566. Land, easements and rights-of-way and the administering of contracts will be provided by the sponsoring local organizations. Local sponsors will obtain these funds and services in the following manner:

a. The Crabtree Creek Watershed Improvement District has been legally organized. This District has the power to let and administer contracts, levy assessments, and limited power of eminent domain. (The power of eminent domain is relevant only when 75 percent of the total easements in a construction unit have been obtained.) The cost of organization of the Watershed Improvement District has been satisfied by Wake County.

b. As a result of contact with landowners concerned, the sponsoring local ogranizations feel that the majority of the land and rights-of-way required for the construction of structural works of improvement will be donated. They feel that the cost of modifications of fixed improvements, such as electric transmission lines and telephone cables can be negotiated, with the owners bearing a portion of these costs. Sewer and water lines will be modified by the city of Raleigh.

c. The sponsoring local organizations have analyzed their financial needs for securing certain land, easements and rights-of-way and have arrived at the following means of providing the necessary funds:

(1) The county of Wake and the city of Raleigh have gone on record agreeing to provide all reasonable means of assistance in the installation of this project. Since 1961, the county and the city have each contributed $3,000 annually to this project and have agreed to continue doing so.

(2) Realtors, individuals, and interested groups have assured the Trustees of the Crabtree Creek Watershed Improvement District that they will give technical and financial assistance in securing those easements and rights-of-way which will not be donated.

(3) The Trustees of the Crabtree Creek Watershed Improve- District are confident that easements secured by donation, plus those secured by financial assistance of realtors, etc., will exceed the 75 percent requirement of the eminent domain provision of State Legislation.

(4) In the event that eminent domain is required to secure the remaining easements, funds can be secured from private sources or by assessment to defray the expenses incurred by condemnation procedures.

(5) The sponsoring local organizations plan to utilize all Federal assistance from programs available or which may be inacted during the installation period of the project.

Federal assistance for carrying out works of improvement as described in the watershed work plan will be provided under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress; 68 Stat. 666), as amended. These monies are contingent on the appropriation of funds for this purpose.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

Land treatment measures, with the exception of cooperative forest fire control, will be maintained in accordance with cooperative agreements

between landowners and operators, and the Neuse River Soil and Water Conservation District. The cooperative forest fire control measures will be operated and maintained by the North Carolina Division of Forestry in cooperation with the U. S. Forest Service.

The Neuse River Soil and Water Conservation District will give attention to the maintenance of adequate vegetative cover on areas which are highly susceptible to erosion. This applies especially to the upper third of the watershed. A good protective cover is essential to the life and proper functioning of the stream channel improvement.

Structural Measures

The Crabtree Creek Watershed Improvement District will be responsible for the operation and maintenance of all structural works of improvement which include 15 floodwater retarding structures, 79,700 feet of stream channel improvement, 1,260 feet of streambank protection and 51,423 feet of clearing and snagging.

Individual landowners upon whose land floodwater retarding structures or portions of these structures are located have indicated to the District that they will enter into an agreement (in the Soil and Water Conservation District Plan) to provide the necessary labor, equipment and materials to perform the normal maintenance on the portion of the structures on their land. The Crabtree Creek Watershed Improvement District assumes the full responsibility for the operation and maintenance of these structures. They will carry out any maintenance measures that are not acceptably accomplished by individual landowners. Funds for this purpose will be provided by the county of Wake and the city of Raleigh.

Stream channel improvement will be maintained as designed and constructed. Sediment bars, undesirable vegetation and debris will be removed; scour holes on bottom and sides will be refilled.

Clearing and snagging will be maintained approximately as constructed, snags and debris in the channels will be removed. Woody growths on the banks will be controlled by mechanical or chemical means.

The streambank protection will be maintained as constructed. Cracks which may appear in the concrete will be caulked. Undercutting or backfill washout will be refilled when they occur.

Representatives of the Crabtree Creek Watershed Improvement District will make annual inspections of all structural works of improvement. Additional inspections will be made after every major storm event. These inspections will determine the condition of the vegetation on

the streambanks, spoil banks, borrow areas, and floodwater retarding structures. They will also ascertain whether logs and other debris are in the channels. The floodwater retarding structures will be inspected to determine that the principal spillway, emergency spillway, trash rack, and toe drain are functioning properly.

A record of maintenance operation and maintenance inspection will be on file with the Crabtree Creek Watershed Improvement District. The State Conservationist's designated Soil Conservation Service employee will make periodic checks, at least annually, to see that adequate maintenance is being performed according to agreements. Specific operation and maintenance agreements will be executed prior to the issuance of invitations to bid on construction or installation of structural works of improvement.

The estimated annual cost of operation and maintenance of structural works of improvement is $39,321, (Table 4).

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

Crabtree Creek Watershed, North Carolina

Installation Cost Items	Unit	Number	Estimated Cost (Dollars) 1/		
			P.L.566	Other	
		Non-Federal Land	Non-Federal Land	Non-Federal Land	Total
LAND TREATMENT					
Soil Conservation Service					
Consv. Cropping System	Acre	6,122		18,366	18,366
Stripcropping	Acre	1,270		24,516	24,516
Cover Crop	Acre	1,673		8,365	8,365
Crop Residue Use	Acre	6,697		13,394	13,394
Diversions	L.Ft.	98,280		4,914	4,914
Field Border Planting	L.Ft.	146,834		4,405	4,405
Terraces	L.Ft.	1,426,320		57,053	57,053
Grassed Waterway or Outlet	Acre	316		31,561	31,561
Perennials in Rotation	Acre	2,271		22,710	22,710
Pasture & Hayland Planting	Acre	1,342		67,100	67,100
Pasture & Hayland Renov.	Acre	1,555		77,750	77,750
Wildlife Habitat Develop.	Acre	120		7,200	7,200
Tile Drains	L.Ft.	82,820		41,410	41,410
Farm Ponds	No.	60		60,000	60,000
Land Smoothing	Acre	763		10,486	10,486
Farm Planning:					
Cooperators	No.	305			
Basic Agricultural	No.	137			
Basic Non-Agricultural	No.	223			
Revisions Basic Agric.	No.	120			
Technical Assistance			150,240	55,440	205,680
SCS Subtotal			150,240	504,670	654,910
Forest Service					
Tree Planting	Acre	1,896		42,500	42,500
Hydrologic Stand Improv.	Acre	2,450		4,000	4,000
Cooperative Forest Fire Control		One Unit	1,450	1,450	2,900
Technical Assistance			14,000	10,000	24,000
FS Subtotal			15,450	57,950	73,400
TOTAL LAND TREATMENT			165,690	562,620	728,310

1/ Price Base: 1962 Date: March 1964

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST (Continued)

Crabtree Creek Watershed, North Carolina

Installation Cost Items	Unit	Number	Estimated Cost (Dollars)[1/]		
			P.L.566	Other	
		Non-Federal Land	Non-Federal Land	Non-Federal Land	Total
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Str.	No.	15	1,042,706		1,042,706
Stream Channel Improvement	L.Ft.	79,700	1,897,253		1,897,253
Streambank Protection	L.Ft.	1,260	142,531		142,531
Clearing & Snagging	L.Ft.	51,423	22,400		22,400
SCS Subtotal - Constr.			3,104,890		3,104,890
Installation Services					
Soil Conservation Service					
Engineering Services			517,870		517,870
Other			235,480		235,480
SCS Subtotal - Installation Services			753,350		753,350
Other Costs					
Land, Easements & R/W				786,670	786,670
Admin. of Contracts				9,900	9,900
SCS Subtotal - Other				796,570	796,570
TOTAL STRUCTURAL MEASURES			3,858,240	796,570	4,654,810
TOTAL PROJECT			4,023,930	1,359,190	5,383,120
SUMMARY					
Subtotal - SCS			4,008,480	1,301,240	5,309,720
Subtotal - FS			15,450	57,950	73,400
TOTAL PROJECT			4,023,930	1,359,190	5,383,120

1/ Price Base: 1962 Date: March 1964

Table 1a - STATUS OF WATERSHED WORKS OF IMPROVEMENT

Crabtree Creek Watershed, North Carolina

Measures	Unit	Applied To Date	Total Cost (Dollars) 1/
LAND TREATMENT			
Conservation Cropping Systems	Acre	1,593	4,779
Contour Farming	Acre	1,250	6,250
Stripcropping	Acre	20	240
Cover Crop	Acre	75	375
Crop Residue Use	Acre	973	1,946
Farm Ponds	No.	130	130,000
Field Border Planting	L.Ft.	9,180	275
Terraces	L.Ft.	579,600	23,184
Grassed Waterways	Acre	65	6,500
Hedgerow Planting	L.Ft.	1,928	116
Grasses & Legumes in Rotation	Acre	284	2,840
Pasture and Hayland Planting	Acre	1,334	66,700
Tree Planting	Acre	80	1,200
Wildlife Habitat Development	Acre	14	840
Diversions	L.Ft.	1,600	80
Tile Drains	L.Ft.	6,200	3,100
TOTAL			248,425

1/ Price Base: 1962 Date: March 1964

TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION

Crabtree Creek Watershed, North Carolina
(Dollars)[1/]

STRUCTURE SITE NO. OR NAME	Installation Cost - P. L. 566 Funds				Installation Cost - Other Funds			
		Instal. Services			Other			Total
	Con-struction	Engin-eering	Other	Total P.L.566	Adm. Contracts	Easements & R/W	Total Other	Installation Cost
Floodwater Retarding Structures No. 1	33,131	6,626	2,586	42,343	500	4,850	5,350	47,693
2	33,022	6,604	2,576	42,202	500	3,410	3,910	46,112
3	45,125	9,025	3,520	57,670	500	6,600	7,100	64,770
5	58,619	11,724	4,572	74,915	500	20,170	20,670	95,585
7	64,473	12,895	5,029	82,397	500	4,760	5,260	87,657
11	50,259	10,052	3,920	64,231	500	6,660	7,160	71,391
13	78,945	15,789	6,158	100,892	500	99,375	99,875	200,767
15	46,939	9,388	3,661	59,988	500	37,700	38,200	98,188
16	32,088	6,418	2,503	41,009	500	15,750	16,250	57,259
18	57,595	11,519	4,492	73,606	500	5,600	6,100	79,706
20	125,136	25,027	9,761	159,924	500	22,600	23,100	183,024
21	45,972	9,194	3,586	58,752	500	3,930	4,430	63,182
22	37,788	7,558	2,947	48,293	500	19,700	20,200	68,493
23	98,103	19,621	7,652	125,376	500	63,970	64,470	189,846
25	235,511	47,102	18,370	300,983	500	30,720	31,220	332,203
Subtotal - Structures	1,042,706	208,542	81,333	1,332,581	7,500	345,795	353,295	1,685,876
Stream Channel Improvement								
Crabtree Creek	1,820,218	273,033	136,061	2,229,312	1,000	371,500	372,500	2,601,812
Marsh Creek	38,987	5,848	2,914	47,749	100	8,550	8,650	56,399
Haresnipe Creek	515	77	39	631		800	800	1,431
House Creek	538	81	40	659		2,040	2,040	2,699
Pigeon House Branch	15,260	2,289	1,141	18,690	100	30,000	30,100	48,790
Big Branch	8,512	1,277	636	10,425	100	7,200	7,300	17,725
Mine Creek	13,223	1,983	988	16,194	100	11,300	11,400	27,594
Subtotal - Stream Channel Improvement	1,897,253	284,588	141,819	2,323,660	1,400	431,390	432,790	2,756,450

1/ Price Base: 1962

TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION (Continued)

Crabtree Creek Watershed, North Carolina
(Dollars)[1/]

STRUCTURE SITE NO. OR NAME	Installation Cost - P.L. 566 Funds				Installation Cost - Other Funds			Total Installation Cost
		Instal. Services			Other			
	Con-struction	Engin-eering	Other	Total P.L.566	Adm. of Contracts	Easements & R/W	Total Other	
Streambank Protection								
Crabtree Creek	142,531	21,380	10,654	174,565	500		500	175,065
Subtotal - Streambank Protection	142,531	21,380	10,654	174,565	500		500	175,065
Clearing & Snagging								
Crabtree Creek	6,586	988	492	8,066	100	1,246	1,346	9,412
Marsh Creek	2,262	339	169	2,770	100	3,050	3,150	5,920
Stirrup Iron Creek	8,042	1,206	601	9,849	100	1,085	1,185	11,034
Briar Creek	2,822	423	211	3,456	100	380	480	3,936
Cole Creek	493	74	37	604		104	104	708
Oxford Branch	851	128	64	1,043		1,400	1,400	2,443
Beaver Dam Creek	1,344	202	100	1,646	100	2,220	2,320	3,966
Subtotal - Clearing & Snagging	22,400	3,360	1,674	27,434	500	9,485	9,985	37,419
Channels - Subtotal	2,062,184	309,328	154,147	2,525,659	2,400	440,875	443,275	2,968,934
Structures - Subtotal	1,042,706	208,542	81,333	1,332,581	7,500	345,795	353,295	1,685,876
TOTAL	3,104,890	517,870	235,480	3,858,240	9,900	786,670	796,570	4,654,810

1/ Price Base: 1962

Date: March 1964

TABLE 3 - STRUCTURE DATA
Floodwater Retarding Structures

Crabtree Creek Watershed, North Carolina

ITEM	UNIT	STRUCTURE NUMBERS 1	2	3	5
DRAINAGE AREA	sq.mi.	2.06	1.43	2.33	8.85
STORAGE CAPACITY					
Sediment	ac.ft.	167	115	188	712
Floodwater	ac.ft.	451	335	564	2,436
TOTAL	ac.ft.	618	450	752	3,148
Between high & low stages	ac.ft.	---	213	364	-----
SURFACE AREA					
Sediment Pool	ac.	18	14	35	100
Floodwater Pool	ac.	63	22	75	365
VOLUME OF FILL	cu.yds.	54,700	37,750	71,650	67,700
ELEVATION TOP OF DAM	ft.	320.5	340.0	356.0	325.5
MAX. HEIGHT OF DAM	ft.	32.0	31.0	32.0	39.5
EMERGENCY SPILLWAY					
Crest Elevation	ft.	315.0	333.0	350.0	319.5
Bottom Width	ft.	260	260	300	500
Type		Veg.	Veg.	Veg.	Veg.
Percent Chance of Use		1	1	1	1
Avg. Curve No. - Cond. II		81	81	81	80
EMERGENCY SPILLWAY HYDROGRAPH					
Storm Rainfall (6-hr.)	in.	10.28	10.28	10.28	12.10
Storm Runoff	in.	7.91	7.91	7.91	7.79
Velocity of Flow (V_c) 1/	ft/sec.	----	3.2	3.5	5.2
Discharge Rate 1/	c.f.s.	----	1,690	1,400	2,110
Max. w.s. elevation 1/	ft.	315.0	337.0	351.3	321.0
FREEBOARD HYDROGRAPH					
Storm Rainfall (6-hr.)	in.	25.08	25.08	25.08	29.50
Storm Runoff	in.	22.47	22.47	22.47	22.31
Velocity of Flow (V_c) 1/	ft/sec.	10.09	9.54	10.53	10.55
Discharge Rate 1/	c.f.s.	8,300	7,300	11,200	20,000
Max. w.s. elevation 1/	ft.	320.5	340.0	356.0	325.5
PRINCIPAL SPILLWAY					
Capacity-low stage	c.f.s.	100	14	23	97
Capacity-high stage	c.f.s.	---	103	151	---
CAPACITY EQUIVALENTS					
Sediment Volume	in.	1.51	1.51	1.51	1.50
Detention Volume	in.	4.10	4.39	4.54	5.43
Spillway Storage	in.	8.72	3.98	4.34	5.82
CLASS OF STRUCTURE		A	A	A	C

1/ Maximum during passage of hydrograph.

Date: March 1964

TABLE 3 - STRUCTURE DATA (Continued)
Floodwater Retarding Structures
Crabtree Creek Watershed, North Carolina

ITEM	UNIT	STRUCTURE NUMBERS 7	11	13	15
DRAINAGE AREA	sq.mi.	3.46	4.57	8.15	2.56
STORAGE CAPACITY					
Sediment	ac.ft.	132	205	403	135
Floodwater	ac.ft.	671	1,069	1,958	594
TOTAL	ac.ft.	803	1,274	2,361	729
Between high & low stages	ac.ft.	---	---	---	---
SURFACE AREA					
Sediment Pool	ac.	11	24	40	15
Floodwater Pool	ac.	58.5	79	236	58
VOLUME OF FILL	cu.yd.	112,800	78,550	150,500	71,300
ELEVATION TOP OF DAM	ft.	316.5	341.5	281.5	270.5
MAX. HEIGHT OF DAM	ft.	46.5	46.0	52.5	45.5
EMERGENCY SPILLWAY					
Crest Elevation	ft.	310.5	336.0	271.5	265.5
Bottom Width	ft.	400	500	320	600
Type		Veg.	Veg.	Veg.	Veg.
Percent Chance of Use		1	1	1	1
Avg. Curve No. - Cond. II		75	76	79	79
EMERGENCY SPILLWAY HYDROGRAPH					
Storm Rainfall (6-hr.)	in.	10.28	9.56	12.10	12.10
Storm Runoff	in.	7.13	6.59	9.40	9.40
Velocity of Flow (V_c)[1/]	ft/sec.	4.9	4.6	7.9	4.8
Discharge Rate[1/]	c.f.s	2,650	2,650	7,190	3,900
Max. w.s.elevation[1/]	ft.	312.5	337.8	275.7	267.5
FREEBOARD HYDROGRAPH					
Storm Rainfall (6-hr.)	in.	25.08	23.30	29.50	29.50
Storm Runoff	in.	21.48	19.88	26.53	26.53
Velocity of Flow (V_c)[1/]	ft/sec.	10.56	10.30	13.60	8.80
Discharge Rate[1/]	c.f.s.	15,000	17,000	31,400	18,000
Max. w.s. elevation[1/]	ft.	316.5	341.5	281.5	270.5
PRINCIPAL SPILLWAY					
Capacity - low stage	c.f.s.	95	110	152	104
Capacity - high stage	c.f.s.	---	---	---	--
CAPACITY EQUIVALENTS					
Sediment Volume	in.	.71	.84	.93	.97
Detention Volume	in.	3.75	4.38	4.50	4.27
Spillway Storage	in.	1.95	1.80	6.42	2.26
CLASS OF STRUCTURE		B	B	C	C

1/ Maximum during passage of hydrograph.

Date: March 1964

TABLE 3 - STRUCTURE DATA (Continued)
Floodwater Retarding Structures
Crabtree Creek Watershed, North Carolina

ITEM	UNIT	STRUCTURE NUMBERS 16	18	20	21
DRAINAGE AREA	sq.mi.	3.15	2.51	11.53	1.88
STORAGE CAPACITIES					
Sediment	ac.ft.	165	96	933	71
Floodwater	ac.ft.	747	619	3,395	327
TOTAL	ac.ft.	912	715	4,328	398
Between high & low stages	ac.ft.	---	---	---	---
SURFACE AREA					
Sediment Pool	ac.	19.5	18	112	10
Floodwater Pool	ac.	89	65	290	41
VOLUME OF FILL	cu.yd.	42,200	104,600	176,300	76,200
ELEVATION TOP OF DAM	ft.	264.5	334.5	334.5	309.0
MAX. HEIGHT OF DAM	ft.	39.5	34.5	43.0	42.0
EMERGENCY SPILLWAYS					
Crest Elevation	ft.	257.0	330.0	319.0	304.5
Bottom Width	ft.	300	400	2@500	400
Type		Veg.	Veg.	Veg.	Veg.
Percent Chance of Use		1	1	1	1
Avg. Curve No. - Cond. II		79	79	80	76
EMERGENCY SPILLWAY HYDROGRAPH					
Storm Rainfall (6-hr.)	in.	12.10	10.28	12.10	10.28
Storm Runoff	in.	9.31	7.66	7.79	7.26
Velocity of Flow (V_c)[1/]	ft/sec.	6.1	4.6	3.7	3.9
Discharge Rate[1/]	c.f.s.	3,040	2,150	3,200	2,650
Max. w.s. Elevation[1/]	ft.	259.8	331.8	320.3	306.5
FREEBOARD HYDROGRAPH					
Storm Rainfall (6-hr.)	in.	29.50	25.08	29.50	25.08
Storm Runoff	in.	26.53	22.15	22.31	21.64
Velocity of Flow (V_c)[1/]	ft/sec.	11.50	9.17	9.91	9.17
Discharge Rate[1/]	c.f.s.	15,800	9,800	31,500	9,800
Max. w.s. Elevation[1/]	ft.	264.5	334.5	334.5	309.0
PRINCIPAL SPILLWAY					
Capacity - low stage	c.f.s.	93	105	107	104
Capacity - high stage	c.f.s.	---	---	---	---
CAPACITY EQUIVALENTS					
Sediment Volume	in.	.98	.71	1.51	.71
Detention Volume	in.	4.64	4.62	4.74	3.26
Spillway Storage	in.	5.39	3.28	2.92	2.05
CLASS OF STRUCTURE		C	A	C	B

1/ Maximum during passage of hydrograph. Date: March 1964

TABLE 3 - STRUCTURE DATA (Continued)
Floodwater Retarding Structures

Crabtree Creek Watershed, North Carolina

ITEM	UNIT	STRUCTURE NUMBERS 22	23	25	TOTAL
DRAINAGE AREA	sq.mi.	3.81	17.79	25.31	99.39
STORAGE CAPACITIES					
Sediment	ac.ft.	191	1,750	483	5,746
Floodwater	ac.ft.	930	4,950	3,650	22,696
TOTAL	ac.ft.	1,121	6,700	4,133	28,442
Between high & low stages	ac.ft.	---	---	---	577
SURFACE AREA					
Sediment Pool	ac.	16	250	---	682.5
Floodwater Pool	ac.	100	1,360	360	3,261.5
VOLUME OF FILL	cu.yd.	51,500	95,450	63,000	1,254,200
ELEVATION TOP OF DAM	ft.	348.0	296.0	266.0	xxxxx
MAX. HEIGHT OF DAM	ft.	45.0	40.0	43.0	xxxxx
EMERGENCY SPILLWAY					
Crest Elevation	ft.	343.5	284.5	252.5	xxxxx
Bottom Width	ft.	300	2@400	2@400	xxxxx
Type		Veg.	Veg.	Veg.	xxxxx
Percent Chance of Use		1	1	1	xxxxx
Avg. Curve No. - Cond. II		79	80	73	xxxxx
EMERGENCY SPILLWAY HYDROGRAPH					
Storm Rainfall (6-hr)	in.	8.80	10.28	9.56	xxxxx
Storm Runoff	in.	6.73	7.79	6.09	xxxxx
Velocity of Flow (V_c) 1/	ft/sec.	4.5	4.7	7.90	xxxxx
Discharge Rate 1/	c.f.s.	1,850	4,235	12,500	xxxxx
Max. w.s. Elevation 1/	ft.	345.5	286.2	255.9	xxxxx
FREEBOARD HYDROGRAPH					
Storm Rainfall (6-hr)	in.	15.40	25.08	23.30	xxxxx
Storm Runoff	in.	12.61	22.31	19.38	xxxxx
Velocity of Flow (V_c) 1/	ft/sec.	6.60	14.38	16.66	xxxxx
Discharge Rate 1/	c.f.s.	6,200	92,500	122,000	xxxxx
Max. w.s. Elevation 1/	ft.	348.0	296.0	266.0	xxxxx
PRINCIPAL SPILLWAY					
Capacity - low stage	c.f.s.	114	1,236	2,185	xxxxx
Capacity - high stage	c.f.s.	---	---	---	xxxxx
CAPACITY EQUIVALENTS					
Sediment Volume	in.	.93	1.85	.36	xxxxx
Detention Volume	in.	4.57	5.22	2.70	xxxxx
Spillway Storage	in.	2.50	13.80	4.93	xxxxx
CLASS OF STRUCTURE		B	C	C	

1/ Maximum during passage of hydrograph

Date: March 1964

TABLE 3A - STRUCTURE DATA

CHANNELS

Crabtree Creek Watershed, North Carolina

Channel Designation	Sta. Numbering For Reach Sta. (ft.)	Sta. (ft.)	Watershed Area[1] (sq.mi.)	Planned Channel Capacity[1] (cfs)	Bottom Width (ft.)	Side Slope[4]	Depth (ft.)	Grade (Pct.)	Velocity (ft./sec.)	Volume of Excavation (cu.yds.)	Volume of Concrete (cu.yds.)
Crabtree Creek	1781+00	1936+23	6.89	997	Clearing & Snagging						
	2475+00	2500+00	5.80	4,150	40	2.5:1	10	0.11	6.50[3]		
	2500+00	2527+85	8.12	4,550	48	2.5:1	10	0.11	6.59		
	2527+85	2550+00	10.10	5,400	56	2.5:1	10	0.11	6.79	105,284	
	2550+00	2570+35	11.30	5,650	58	2.5:1	10	0.11	6.82		
	2570+35	2590+00	12.43	6,200	66	2.5:1	10	0.11	6.92	44,325	
	2590+00	2610+00	13.51	6,600	68	2.5:1	10	0.11	6.95		
	2610+00	2630+00	13.51	6,622	70	2.5:1	10	0.11	6.97	41,604	
	2630+00	2650+00	17.41	6,819	72	2.5:1	10	0.11	7.03		
	2650+00	2672+00	18.35	7,750	80	2.5:1	11	0.11	7.27	47,914	
	2672+00	2720+00	20.70	8,400	86	2.5:1	11	0.095	6.91		
	2720+00	2745+00	21.34	8,800	96	2.5:1	11	0.095	6.49	263,793	
	2745+00	2767+50	22.20	9,302	102	2.5:1	11	0.080	6.52		
	2767+50	2770+00	22.69	9,619	106	2.5:1	11	0.08	6.55		
	2770+00	2790+00	23.47	9,370	110	2.5:1	11	0.08	6.57		
	2790+00	2815+00	24.45	9,940	112	2.5:1	11	0.08	6.59		
	2815+00	2842+50	25.50	10,500	116	2.5:1	11	0.08	6.61		
	2842+50	2870+00	26.56	10,936	122	2.5:1	11	0.08	6.65		
	2870+00	2885+00	33.56	12,100	120	2.5:1	13	0.06	6.42	371,776	
	2885+00	2898+35	34.34	12,350	122	2.5:1	13	0.06	6.32		
	2898+35	2925+00	35.96	12,615	124	2.5:1	13	0.06	6.33		
	2925+00	2953+35	38.58	13,055	140	2.5:1	13	0.05	6.34	444,832	
	2953+35	3036+85	36.32	13,563	146	2.5:1	13	0.05	5.86		
	3036+85	3097+00	41.96	13,900	150	2.5:1	13	0.05	5.90	460,143	
	2773+00	2785+60									1,386[2]

1/ Apply at lower end of reach.
2/ Retaining wall adjacent to Farmers Market from Sta. 2773+00 to 2785+60 at U.S. 401 & U. S. 1
3/ N = .0275
4/ Variations to meet physical conditions, including sloping from one side only.

TABLE 3A - STRUCTURE DATA (Continued)

CHANNELS

Crabtree Creek Watershed, North Carolina

Channel Designation	Sta. Numbering For Reach Sta. (ft)	Sta. (ft)	Watershed Area[1] (sq.mi.)	Planned Channel Capacity[1] (cfs)	Bottom Width (ft.)	Side Slope[4]	Depth (ft.)	Grade (Pct.)	Velocity (ft./sec.)	Volume of Excavation (cu.yds.)	Volume of Concrete (cu.yds.)
Stirrup Iron Creek	10+00	195+55	1.45	291	Clearing & Snagging						
Briar Creek	10+00	76+52	3.43	153	Clearing & Snagging						
Cole Branch	10+00	21_61	Release Route FRS #18	105	Clearing & Snagging						
Marsh Creek	10+00	63+32	2.00	93	Clearing & Snagging						
	63+32	133+32	5.77	1,803	20	2.5:1	7.5	0.32	6.92	94,288	
Pigeon House Br.	10+00	30+00	4.28	1,716	30	2.5:1	7.0	0.20	5.57	34,720	
Oxford Branch	10+00	30+39	1.20	375	Clearing & Snagging						
Beaver Dam Crk.	10+00	31+71	3.51	1,320	Clearing & Snagging						
Mine Creek	10+00	46+00	1.47	814	20	2.5:1	6.0	0.29	5.22	13,041	
	46+00	54+00	1.47	814	20	2.5:1	7.0	0.17	4.33	8,402	
Big Branch	10+00	43+00	0.92	596	12	2.5:1	6.5	0.21	4.94	15,010	
Hare Snipe Crk.	10+00	14+00	3.14	1,095	18	2.5:1	7.0	0.28	6.28	1,030	
House Creek	10+00	14+00	2.78	1,051	18	2.5:1	7.0	0.26	6.11	1,080	

1/ Apply at lower end of reach.
4/ Variations to meet physical conditions, including sloping from one side only.

Date: March 1964

TABLE 4 - ANNUAL COST

Crabtree Creek Watershed, North Carolina

(Dollars)

Evaluation Unit	Amortization of Installation Cost 1/	Operation and Maintenance Cost 2/	Total
All Structural Works of Improvement	180,932	39,321	220,253
TOTAL	180,932	39,321	220,253

1/ Price base: 1962 - 50-year evaluation period at 3.0 percent interest. Date: March 1964

2/ Long term projected prices.

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Crabtree Creek Watershed, North Carolina

(Dollars)[1/]

Item	Estimated Average Annual Damage		Damage Reduction Benefit
	Without Project	With Project	
Floodwater			
Crop and Pasture	3,378	154	3,224
Nonagricultural:			
Residential, Commercial, Industrial Properties	72,496	0	72,496
Subtotal	75,874	154	75,720
Indirect	13,132	15	13,117
TOTAL	89,006	169	88,837

1/ Long term projected prices.

Date: March 1964

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Crabtree Creek Watershed, North Carolina

(Dollars)[1/]

Evaluation Unit	AVERAGE ANNUAL BENEFITS					Avg. Annual Cost	Benefit Cost Ratio
	Flood Prevention						
	Damage Reduction	More Intensive Land Use		Secondary	Total		
		Agric.	Urban				
All Structural Works of Improvement	75,512	3,439	481,377	54,952	615,280	220,253	2.8:1.0
GRAND TOTAL	75,512[2/]	3,439	481,377	54,952	615,280	220,253	2.8:1.0

1/ Price base: Benefits are long term projected and cost 1962, (See Table 4.)

Date: March 1964

2/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $13,325 annually.

INVESTIGATIONS AND ANALYSES

Summary

The project objectives dictated the type and extent of investigations and analyses. Land treatment measures were considered as the first element of control. Their benefit will be neutralized, to a large extent, by the expanding urbanization of the area adjacent to the city of Raleigh and the outlying areas of the city of Durham.

An analysis of the expected land use changes based on projected population estimates indicates that runoff characteristics from the agricultural portions of the watershed will improve. Some areas now in agricultural use will, within the benefit period of the project, be converted to urban areas and the runoff characteristics from these areas can be expected to degrade. The result is that the runoff characteristics of the entire watershed will not be improved by the installation of the project.

In the selection of structural works of improvement to be included in investigations and analyses, preliminary findings demonstrated that the maximum use of floodwater retarding structures would be essential. It was recognized that stream channel improvement would be necessary also. Investigations and analyses were directed toward reducing flows to the minimum for floodwater retarding structures and then enlarging channels to the extent necessary to keep a 100-year frequency storm within bank-full stage in the highly developed urban and industrial areas.

The area between Lassiter's Mill and a point one-mile below U. S. Highway No. 64 was investigated to determine whether a more economical channel with improved alignment could be obtained. This investigation resulted in seven relocations which reduced the channel length through this area by 2.2 miles.

Further investigations were made to determine the most economical cross sectional area of channel to be installed, giving adequate consideration to rock and other construction problems. Investigations and analyses were tempered by the fact that under future conditions hundres of lives would be endangered by failure of structural works of improvement.

Lassiter's Mill is no longer used for power development and its value for recreation is limited. Therefore, the channel was designed with the dam removed. Should the dam not be removed, channel improvement above the dam would be materially reduced. The sponsoring local organizations have stated that it will be removed.

Investigations in the agricultural areas were directed toward providing three- to five-year flood protection.

The value of land, easements and rights-of-way, other than public utilities, were determined by the Trustees of the Crabtree Creek Watershed Improvement District. Costs of modifications and/or alterations of public utilities were determined by the owner of the utilities. All costs for land, easements and rights-of-way were concurred in by the Soil Conservation Service.

Land Use and Treatment

Present major land use was obtained from the soil conservation surveys with modifications made to correct for urbanization which has occurred since the survey. Detailed information pertaining to cultivated land was furnished by the work unit conservationists and soil scientists.

The increase in the urban area was developed from projections made by the cities of Raleigh and Durham.

Estimates of land treatment measures and practices to be included in the plan were developed by the work unit conservationists and concurred in by the Neuse River Soil and Water Conservation District. These estimates were based on an analysis of farm soil and water conservation plans which have been developed in the watershed and through a study of the conservation needs developed for the counties.

Forest land conditions were determined by a field survey. Hydrologic and stand conditions and treatment needs were inventoried on 100 sample plots systematically scattered throughout the watershed. These field determinations were supplemented with data from other surveys, consultation with other agencies, and discussions with forestry officials to determine quantities of measures needed. However, program recommendations include only that amount of betterment work that can be installed during the program installation period and include only measures that contribute directly to flood prevention and soil stabilization.

Soil Conditions

A sample conservation survey was completed in 1958 by soil scientists of the Soil Conservation Service. The survey furnished information as to soil types, slope, degree of erosion and land use. This information was compiled into usable data by the weighing process which indicated the number of acres in each soil condition by present land use and capability class. The number of acres in each hydrologic condition was tabulated for the hydrologist.

Geology

Geologic investigations consisted of a study of surface features to

determine jointing or faulting or other structural geologic conditions which would affect the design or operation of the proposed installations.

Outcrops of hard rocks were abundant and were used in the investigations. Road cuts were examined. Hand augers were used to study overlying material and depth in bedrock in borrow areas and structure sites. The information thus obtained was utilized in developing preliminary structural designs.

Power auger investigation was made on the major channel relocations. This investigation shows that rock excavation will be limited to occasional ledges and shoals. Rock excavation will not be prohibitive.

Sediment

Determination of sediment damages was accomplished by field examination of the entire flood plain area.

Rates of soil movement and sediment production from sheet erosion were determined by using Musgrave's Formula which takes into account soil decline, percent of slope, length of slope, rainfall, and cover conditions.[1/] Data for the formula were obtained from weighed acreage measurements of soil surveys of the watershed. Rates were determined for each land resource area and for each land use respectively. Cover factors used in the determination of future rates of soil movement were computed from anticipated use of the land in the future.

Sediment storage was computed for each floodwater retarding structure separately. An analysis was made of the cover complex, sheet erosion, and channel erosion on the watershed controlled by each individual structure. The total soil movement was determined, and appropriate delivery ratios were applied to calculate sediment storage requirements.

Hydrologic and Hydraulic Analysis

A total of 15 dams, in addition to channel improvement within the urban part of the watershed, were considered in the analysis. These structures, with drainage areas ranging from 1.43 to 25.31 square miles, control 70 percent of the total drainage area in the watershed.

A total of 19 evaluation reaches (seven in the urban section and 12 in the agricultural area) were used in the analysis. A total of 62 cross sections (55 valley, six bridge, and one dam) were taken to represent the flood plain area.

1/ Musgrave, G. W., "The Quantative Evaluation of Factors in Water Erosion", Journal of Soil and Water Conservation.

Rainfall amounts used in developing the historical storm series were taken from local climatological data. Distribution of rainfall for the watershed was made by Thiessen Weighting Method. The weighted average representation for each of the seven stations used in making up the Thiessen maps ranges from a high of 72.4 percent to a low of 2.5 percent of the total watershed. Intermediate values are: 57.0 percent, 32.3 percent, 31.7 percent, 18.6 percent, and 13.9 percent respectively.

Weather Bureau Technical Publication No. 40 was used to obtain rainfall amounts for the purpose of flood routing. Since there are no stream gaging stations in the watershed, it was necessary to check the flood routed peaks against "regional analysis" studies for the same physiographic area.

Soil-cover-complex runoff curves were computed for the watershed as a whole, and for each individual structure site. Soil and cover conditions for nine sample areas, or 36.3 percent of the total watershed, were mapped for this purpose. The sample areas were selected in such a manner that they would properly reflect runoff conditions from the triassic, crystalline, and urban areas in the watershed. Runoff curves for the wooded areas were furnished by the U. S. Forest Service.

Flood routing for present conditions was done by the Storage Indication Method, which was also used for future conditions in the agriculture portion of the watershed. Peak discharges for the two-year and 50-year events were obtained by flood routing; additional values, including the five-, ten-, 25-, and 100-year events, were determined by the frequency procedure. Concordant flow was used for obtaining peak discharge values within a given routing reach. Hydrograph computations were made by the peak rate equation. Durations for routed storms were estimated from local recording gages.

Future conditions within the urban area were obtained by routing the 100-year, 12-hour storm from Technical Publication No. 40, with Antecedent Moisture Condition II. This routing was done by the Wilson Graphical Procedure, as described in Part 3.17 of Section 5, Supplement A to the National Engineering Handbook. Peak discharge values determined in the above manner are the basis for design of all channel improvements.

Stage-discharge relationships were made by the water surface profile procedure in the urban area, and by Manning's Formula in the agriculture portion of the watershed. Water surface profiles were made by the IBM 650 electronic computer, in accordance with the procedure outlined in Washington Technical Release No. 14. Roughness coefficients for use in rating curve computations by Manning's Formula were estimated in accordance with the procedure outlined in Supplement B to Section 5 of the National Engineering Handbook. Slopes were estimated

from stream and valley profiles.

Acres inundated by depth increments were computed for each of the evaluation reaches. This information was furnished by the electronic computer for the urban area, and was then checked by direct measurement. These calculations were used to determine the total acres flooded and depths of flooding, by reaches, for each of the 50 damage producing storms in the 20-year historical series. Stages at each cross section for the two-, five-, ten-, 25-, 50-, and 100-year events were also determined for the urban area.

The flood of May 12, 1957, the largest in the 20-year historical series, was also routed in order to check floodmarks, and to ascertain the adequacy and accuracy of the overall study. Rainfall amounts for this storm were obtained by plotting an isohyetal map from values observed at local gaging stations. The storm duration was estimated from cumulative rainfall curves of two local recording gages.

Wildlife

A reconnaissance study of the Crabtree Creek Watershed was made by the U. S. Department of Interior, Fish and Wildlife Service, Bureau of Sports Fisheries and Wildlife in cooperation with the North Carolina Wildlife Resources Commission. A summary of their findings is as follows:

a. Fish and wildlife resources will not be significantly affected by the watershed protection and flood prevention measures contemplated.

b. Opportunities for improving the fish and wildlife habitat will occur with the installation of the proposed structural works of improvement. Benefits from possible improvements will be in proportion to effort expended in management.

c. No detailed studies by the Bureau, as provided for in Sections 5 and 6 of the May 12, 1955 Memorandum of Understanding, are deemed necessary.

A copy of the complete report is in the Watershed Case Files.

Stream Sanitation

The following information was furnished by the North Carolina Department of Water Resources, Stream Sanitation Committee:

The town of Cary discharges effluent from a secondary treatment plant

(trickling filter) into Coles Branch, 2.6 miles from the confluence with Crabtree Creek. This plant serves 1,476 people plus connections since survey of 1954. It also serves an industrial population equivalent of 548 from Taylor Food Company.

Raleigh-Durham Airport discharges effluent from secondary treatment plant (septic tank and sand filter) into Little Briar Creek, 4.1 miles from the confluence with Crabtree Creek. This plant serves 75 people plus transients through the airport.

Engineering

Vertical control was established on all floodwater retarding structures using mean sea level as datum.

A baseline was located on the right side of Crabtree Creek channel from junction of Hare Snipe Creek to U. S. Highway No. 64. At U. S. Highway No. 64, the baseline was shifted to left side of Crabtree Creek and continued to Neuse River. The baseline was established on mean sea level datum and was used to locate and run valley cross sections. The same baseline was used to survey and construct a one-foot contour map of the area in and adjacent to Raleigh.

The city of Raleigh provided a contour map with five-foot contour intervals. This map was converted into a one-foot map by utilizing valley and channel cross sections.

Topographic surveys of the floodwater retarding structures were accomplished by use of engineer's transit.

The preliminary design of floodwater retarding structures was made in accordance with Engineering Memoranda SCS-16, SCS-27, SCS-34, SCS-42 (Rev. 2), SCS-43, NC-15, NC-16 and NC-17.

Floodwater retarding structures Nos. 1, 2, 3, 5, 7, 18, 20, and 21 are in series with structure No. 23 and structures Nos. 11 and 23 are in series with floodwater retarding structure No. 25. Floodwater retarding structures Nos. 2, 3, and 18 have two-stage principal spillway designs with approximately Q_5 to Q_{10} storm runoff in low stage detention storage.

Floodwater retarding structures Nos. 5 and 20 have drawdown times in excess of ten days; therefore, spillway flood routing was started at ten day drawdown. Structure No. 25 has no submerged sediment pool and allows free passage of Q_5 frequency storm. This structure is designed to reduce the peak flow at the beginning of channel improvement three miles below.

Detention and Sediment Storage

All structures were designed to control runoff from a 100-year frequency storm as this is the protection being provided to the industrial and urban areas in and adjacent to the city of Raleigh.

Sediment storage was allowed as follows: Fifty percent of the 100-year sediment yield is stored above the permanent pool but below the detention storage. Trap efficiency of structure No. 25 is such that one-half the amount of sediment yield was stored.

Special Problems

To comply with the request of the State Park Directors, a drawdown time of approximately two days was used in floodwater retarding structure No. 25 to protect "rare ornamental plants" located slightly above a flood plain in Reedy Creek State Park. A release rate of 15 CFSM for the entire drainage area above the structure required two 7' x 9' monolithic concrete tubes. The high spillway site required an additional amount of storage to be used in order to eliminate excessive cuts in constructing the required width and depth of spillway. Five designs were analyzed to obtain the most economic design to meet the controlling criteria of storage, maximum elevation and discharge rate.

Emergency and Freeboard Hydrographs

In accordance with Engineering Memorandum SCS-27, emergency and freeboard hydrographs were constructed to determine the design depth of flow in emergency spillway and freeboard respectively. The same hydrographs were used to compete velocity of flow in spillways.

Channel Design

Four alternate designs of the channel through Raleigh were made. An earth channel was designed with and without structure No. 25. A concrete channel was then designed with and without flood retarding structure No. 25. These investigations indicated the need for floodwater retarding structure No. 25 and an enlarged earth channel from Hare Snipe Creek to the Neuse River with the Lassiter's Mill dam being removed.

Marsh Creek, Mine Creek, Pigeon House Branch and Big Branch will have newly constructed or improved channels through the flood plain area of the main stem. Side slopes and 20-feet of berm are to be seeded.

House Creek, Oxford Branch, and Beaver Dam Creek will require clearing and snagging.

In agricultural reaches, tributary channels from floodwater retarding structure No. 3 to Morrisville, floodwater retarding structure No. 5 to Crabtree Creek, floodwater retarding structure No. 20 to Stirrup Iron Creek, floodwater retarding structure No. 18 to Crabtree and Marsh Creeks above U. S. Highway No. 401 to floodwater retarding structure No. 16, will be cleared and snagged.

The earth channels were designed using Manning's Formula and an "n" value of .0275. Tributary channels are to be improved through the flood plain areas adjacent to Crabtree Creek. Minor tributaries and surface water will enter through pipe drop inlets.

Rights-of-Way: Spoil, seeding and maintenance -

Permanent rights-of-way for earth channel consist of approximately 75 feet on each side of the improved channel. A 25-foot berm was placed on each side of channel, to allow for streambank erosion or meandering while channel is becoming stabilized. A maintenance berm of 100 feet total, or 50 feet on each side, was planned. Spoil will be spread four-feet deep on the maintenance berm and the berm will be seeded. Pipe drop inlets will be placed under the spoil in places where surface water and minor tributaries enter the improved channel. All side slopes will be seeded.

Economics

Land use and yield information used in the economic evaluation of the agricultural areas of this watershed was obtained from interviews with farmers who operate approximately 90 percent of the crop and pasture land in the watershed.

Present land use, value of properties, and damages in the urban area were determined on 100 percent of the urban flood plain. Property owners, realtors, insurance agents, and local appraisers were contacted as to present values and damages that have accrued to existing structures in the flood plain. Projected usage was based on information obtained from owners and from county and city zoning agencies.

The present density of residential property in Raleigh is 4.3 dwelling units per acre; however, in one reach there is an area of less density and higher priced homes. This area is projected at 2.5 houses per acre, with the remaining residential property projected at four houses per acre. The present rate of development in this area is such that, with protection, full utilization can be expected in five years.

Basic data pertaining to the agricultural area of this watershed was obtained from local farmers and farm machinery dealers, agricultural

workers, experiment stations, and Department of Agriculture publications. Basic data related to the urban area was obtained from owners, local builders, experiment stations, and Department of Commerce publications.

Damageable values, stage-area relationships, flood series, and depth and length of inundations were considered in estimating average annual damages with and without the project.

Highway and railroad officials stated that modifications of their installations have practically eliminated floodwater damages.

Value of land involved in structural works of improvement was determined by the Trustees of the Crabtree Creek Watershed Improvement District and concurred in by the Service. Easements for utilities were determined by the management of the utilities concerned.

Estimates of production cost, operation and maintenance cost, and benefits are based on long term projected prices, with calculations based on the use of a 3.0 percent interest rate.

A further explanation of evaluation made in the area benefited by structural measures is shown in the following tables.

SUMMARY OF RESTORATION AND MORE INTENSIVE USE OF LAND

Crabtree Creek Watershed, North Carolina

(Dollars)[1/]

Land Use	Without Project Conditions				With Project Conditions			
	Acres	Weighted Average Yield	Gross Value	Net Returns	Acres	Weighted Average Yield	Gross Value	Net Returns
Corn	121	60 bu.	10,527	5,548	121	75 bu.	13,159	7,442
Wheat & Lespedeza Hay	36	30 bu., 1.3 T	3,064	827	36	40 bu., 1.0 T	3,362	900
Oats & Lespedeza Seed	29	60 bu.,250 lbs.	2,590	975	29	70 bu., 225 lbs.	2,730	1,066
Tobacco	14	1,600 lbs.	10,080	3,038	14	2,000 lbs.	12,600	4,288
Ladino Fescue Pasture	63	6 AUM	1,774	483	63	7 AUM	2,079	646
Total	263		28,035	10,871	263		33,930	14,342

1/ Long term projected prices.

Increased Net Returns	3,471
Less Added Floodwater Damage	32
Average Annual Benefit	3,439

Date: March 1964

PROJECTED USAGE OF URBAN FLOOD PLAIN ACREAGE
AS ZONED BY WAKE COUNTY AND CITY OF RALEIGH

Crabtree Creek Watershed, North Carolina

Projected Usage	Flood Plain Ac. in 100-Year Storm (Present Conditions)	Ac. Subject to Flooding After Project in 100-Year Storm	100-Year Present Minus 100-Yr. Future	Present Development	Easements and Backwater Area	To Be Developed
Residential	724	71	653	55	117	481
Industrial	800	61	739	53	109	577
Parks	127	20	107	0	25	82
Neighborhood Business	68	6	62	10	0	52
Shopping Center	58	0	58	0	0	58
Office & Institutional	4	0	4	0	0	4
Total	1,781	158 1/	1,623	118	251 1/	1,254

1/ No benefits claimed in these areas.

Date: March 1964

RESIDENTIAL[1/]

2.5 Houses Per Acre

Capital Cost		
Land (5 lots per 2 acres)	@ $4,000 per lot	$ 20,000
Residences - 5	@ $20,000	100,000
Total Capital Cost		$120,000
Annual Cost		
Lot cost @ 6%		$ 1,200
Houses amortized - 50 years @ 6% (.06344)		6,344
Taxes		1,200
Insurance		450
Maintenance		1,000
Total Annual Cost		$ 10,194
Income		
Rent $180 per month for 5 houses x 12 months		$ 10,800
Minus Annual Cost		10,194
		$ 606
$606 ÷ 2 =		$ 303
Discount for lag in accrual (6% - 5 years)(.887)[2/]		$ 269

1/ Long term projected price.

2/ Page 11, Appendix A, Economics Guide

RESIDENTIAL[1/]

4.0 Houses Per Acre

Capital Cost	
Land (4 lots per acre) @ $2,500	$10,000
Residences - 4 @ $12,500	50,000
Total Capital Cost	$60,000
Annual Cost	
Lot cost @ 6%	$ 600
Houses amortized - 50 years @ 6% (.06344)	3,172
Taxes	600
Insurance	200
Maintenance	500
Total Annual Cost	$ 5,072
Income	
Rent $120 per month for 4 houses x 12 months	$ 5,760
Minus Annual Cost	5,072
	$ 688
Discounted for lag in accrual (6% - 5 years)(.887)[2/]	$ 610

1/ Long term projected prices.

2/ Page 11, Appendix A, Economics Guide.

EVALUATION OF OFFICE AND INSTITUTIONAL PROPERTIES, INDUSTRIAL PROPERTY, NEIGHBORHOOD BUSINESS AND SHOPPING CENTER PROPERTY

Future market value of land, $10,000 per acre minus $2,000 present market price = $8,000 increase due to project x 6% interest = $480 discounted for lag in accrual (6% - 5 years)(.887)[1/] = $426.

EVALUATION OF PARK PROPERTY

Future market value of land, $4,000 per acre minus $1,000 present market price = $3,000 increase due to project x 6% interest = $180.

1/ Page 11, Appendix A, Economics Guide.

URBAN ENHANCEMENT SUMMARY (Dollars)[1/]

Projected Usage	Acres	Net Acres[2/]	Per Acre	Total Benefit
Residential (2.5 HPA)	105	89	269	23,941
Residential (4 HPA)	376	320	610	195,200
Industrial	577	490	426	208,740
Parks	82	70	180	12,600
Neighborhood Business	52	44	426	18,744
Shopping Center	58	49	426	20,874
Office & Institutional	4	3	426	1,278
Total	1,254	1,065		481,377

Date: March 1964

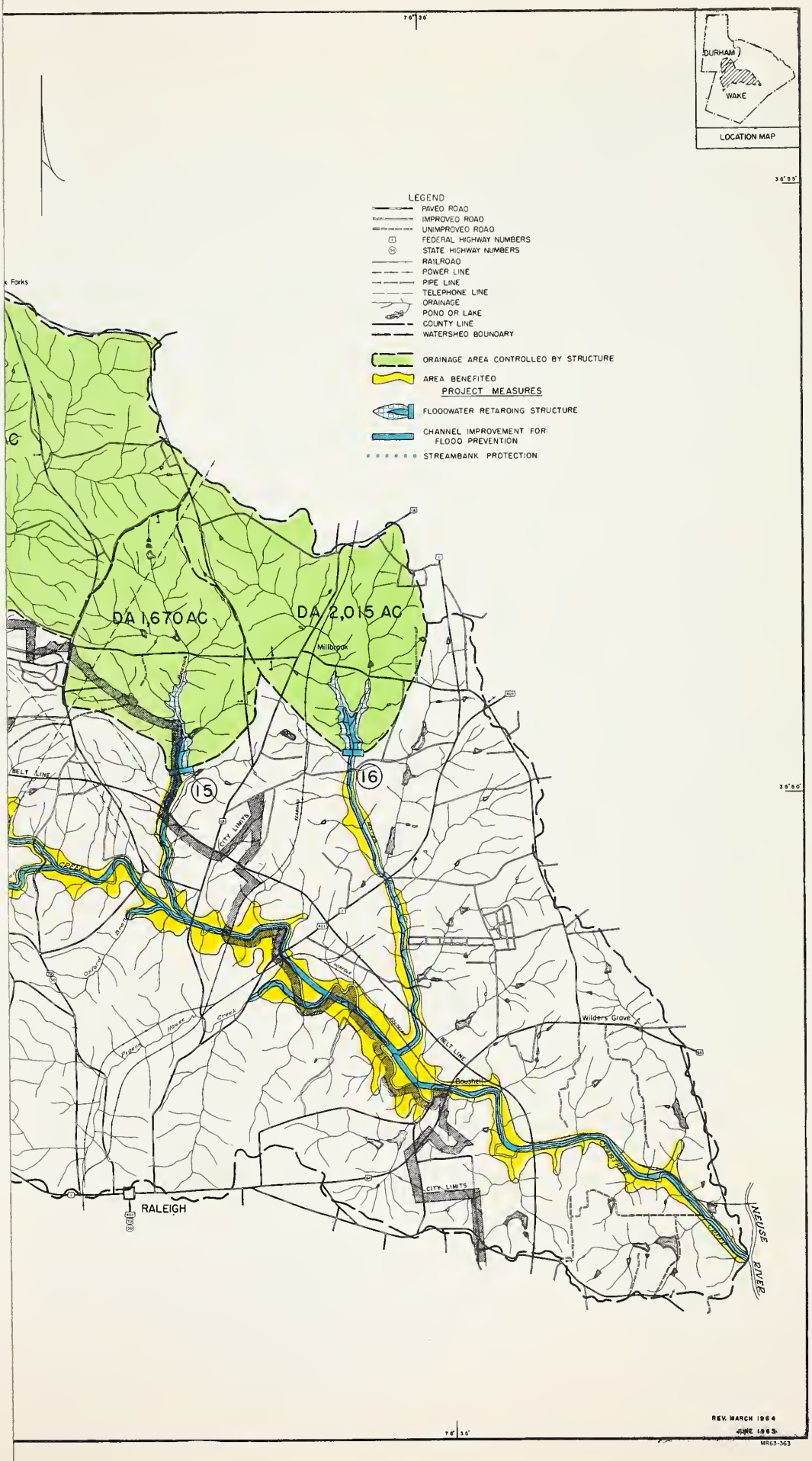
1/ Long term projected prices.
2/ 15% subtracted for roads, streets, undeveloped areas, etc.

SECONDARY URBAN AND AGRICULTURAL BENEFITS
(Dollars)[1/]

Item	Amounts	Secondary Benefits
Direct primary benefits	547,211 x 10%	54,721
Added crop and pasture production cost	2,313 x 10%	231
		54,952

1/ Long term projected prices

Date: March 1964


DURHAM
WAKE
LOCATION MAP
LEGEND
PAVED ROAD
IMPROVED ROAD
UNIMPROVED ROAD
FEDERAL HIGHWAY NUMBERS
STATE HIGHWAY NUMBERS
RAILROAD
POWER LINE
PIPE LINE
TELEPHONE LINE
DRAINAGE
POND OR LAKE
COUNTY LINE
WATERSHED BOUNDARY
DRAINAGE AREA CONTROLLED BY STRUCTURE
AREA BENEFITED
PROJECT MEASURES
FLOODWATER RETARDING STRUCTURE
CHANNEL IMPROVEMENT FOR FLOOD PREVENTION
STREAMBANK PROTECTION
DA 1,670 AC
DA 2,015 AC
Millbrook
15
16
BELT LINE
CITY LIMITS
Oxford Rd.
Wilders Grove
Boonshell
RALEIGH
NEUSE RIVER
35°55'
36°00'
78°35'
REV. MARCH 1964
JUNE 1963
MR63-363

DA 5,683 AC

DA 7,376 AC

DA 2,426 AC

DA 5,219 AC

DA 1,320 AC

DA 1,205 AC

DA 16,285 AC

DA 1,670 AC

DA 2,015 AC

DA 1,386 AC

DA 2,215 AC

DA 2,928 AC

DA 916 AC

DA 1,607 AC

DA 1,491 AC

RALEIGH

DURHAM

WAKE

LOCATION MAP

LEGEND

- PAVED ROAD
- IMPROVED ROAD
- UNIMPROVED ROAD
- FEDERAL HIGHWAY NUMBERS
- STATE HIGHWAY NUMBERS
- RAILROAD
- POWER LINE
- PIPE LINE
- TELEPHONE LINE
- DRAINAGE
- POND OR LAKE
- COUNTY LINE
- WATERSHED BOUNDARY
- DRAINAGE AREA CONTROLLED BY STRUCTURE
- AREA BENEFITED

PROJECT MEASURES

- FLOODWATER RETARDING STRUCTURE
- CHANNEL IMPROVEMENT FOR FLOOD PREVENTION
- STREAMBANK PROTECTION

U S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

PROJECT MAP
CRABTREE CREEK WATERSHED

A PORTION OF

DURHAM AND WAKE COUNTIES

NORTH CAROLINA

JUNE 1958

1. Residential area of Raleigh flooded by storm of May 1957.

2. Farmers Market flooded by storm of May 1957.

3. Storm of May 1957 damages mill on Crabtree

4. Valuable flood plain land in suburbs of Raleigh inundated by storm of May 1957.

5. Buildings, vehicles and equipment flooded by storm of May 1957.

6. Vehicles caught by quick flooding by storm of May 1957.

7. More than 50 homes similar to these were damaged by inundation from storm of May 1957. Over 150 homes would be affected by a similar storm now.

8. In many instances home facilities were damaged when homes were above high water for the storm event of May 1957.

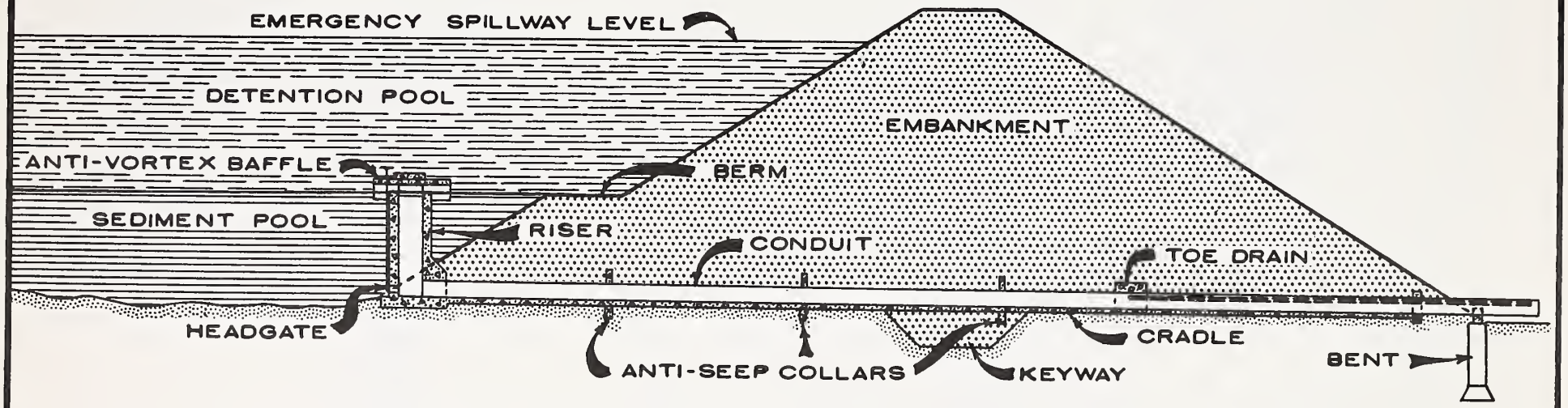
9. Floodwater ripped up asphalt paved parking lot in storm of May 1957.

10. Streets covered by floodwater in suburbs of Raleigh, storm of May 1957.

USDA-SCS-SPARTANBURG, S. C. 1963

UNITED STATES
DEPARTMENT OF AGRICULTURE

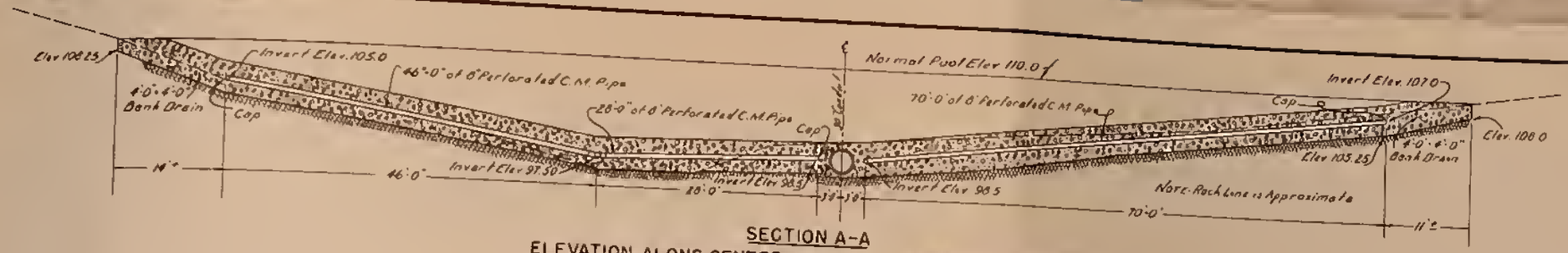
SOIL CONSERVATION SERVICE
SPARTANBURG, SOUTH CAROLINA



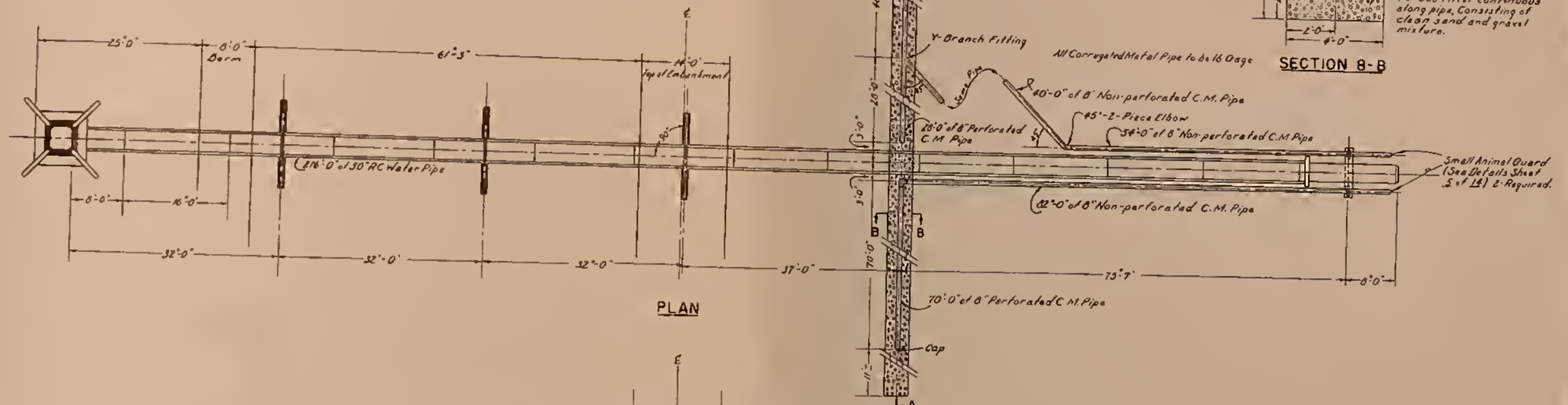
SECTION OF A TYPICAL
FLOODWATER RETARDING STRUCTURE

AGR. SCS. SPARTANBURG, S.C. 1956 REPRINTED 1960

MR56-209

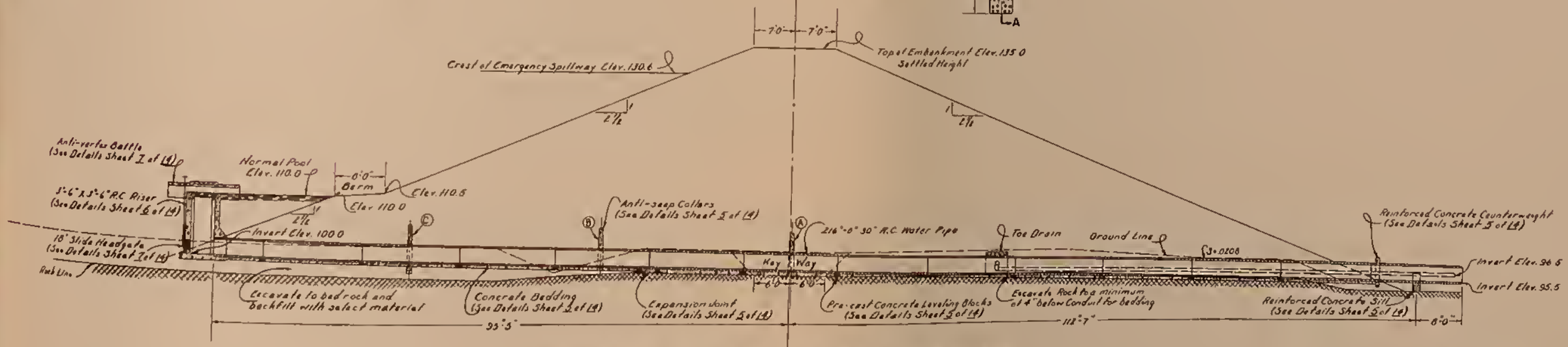


SECTION A-A
ELEVATION ALONG CENTERLINE OF 8" PERFORATED C.M. PIPE



PLAN

SECTION B-B



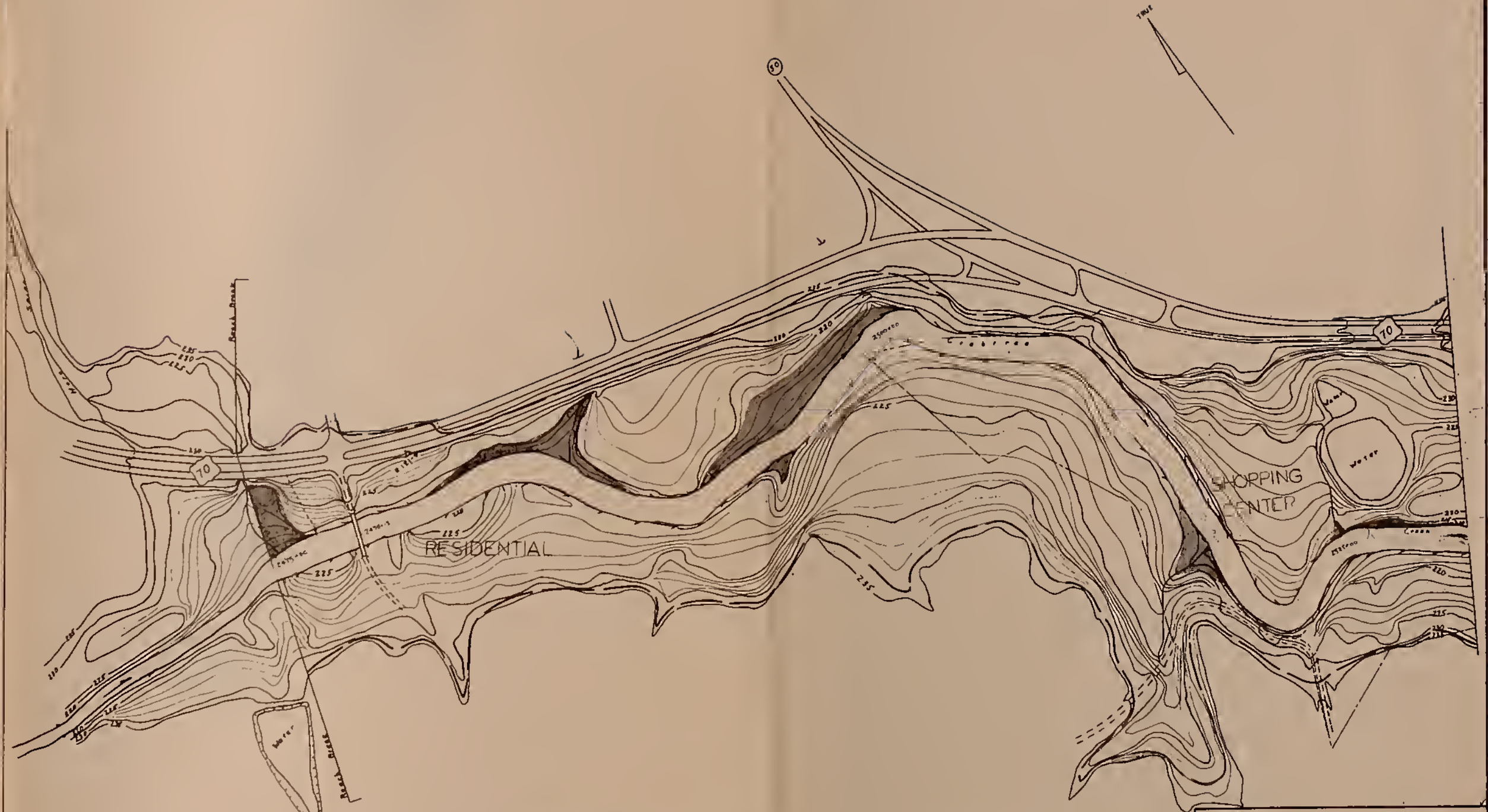
SECTION ALONG CENTERLINE OF 30" REINFORCED CONCRETE PIPE
STA. 4+33 CENTERLINE OF DAM

PLAN
TYPICAL FLOODWATER
RETARDING STRUCTURE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Date	Approved by
Designed	Title STATE CONSERVATION ENGINEER
Drawn	
Traced	Title C.W.P.A. - REGIONAL ENGINEER
Checked	Sheet No. of / Drawing No.

NRS6-201



LEGEND

AREA SUBJECT TO INUNDATION AFTER PROJECT INSTALLATION

100-YEAR FLOOD - PRESENT CONDITIONS

100-YEAR NEUSE RIVER BACK WATER

Contour Interval: 1 ft.
Scale in Feet

... Proposed Channel Improvement

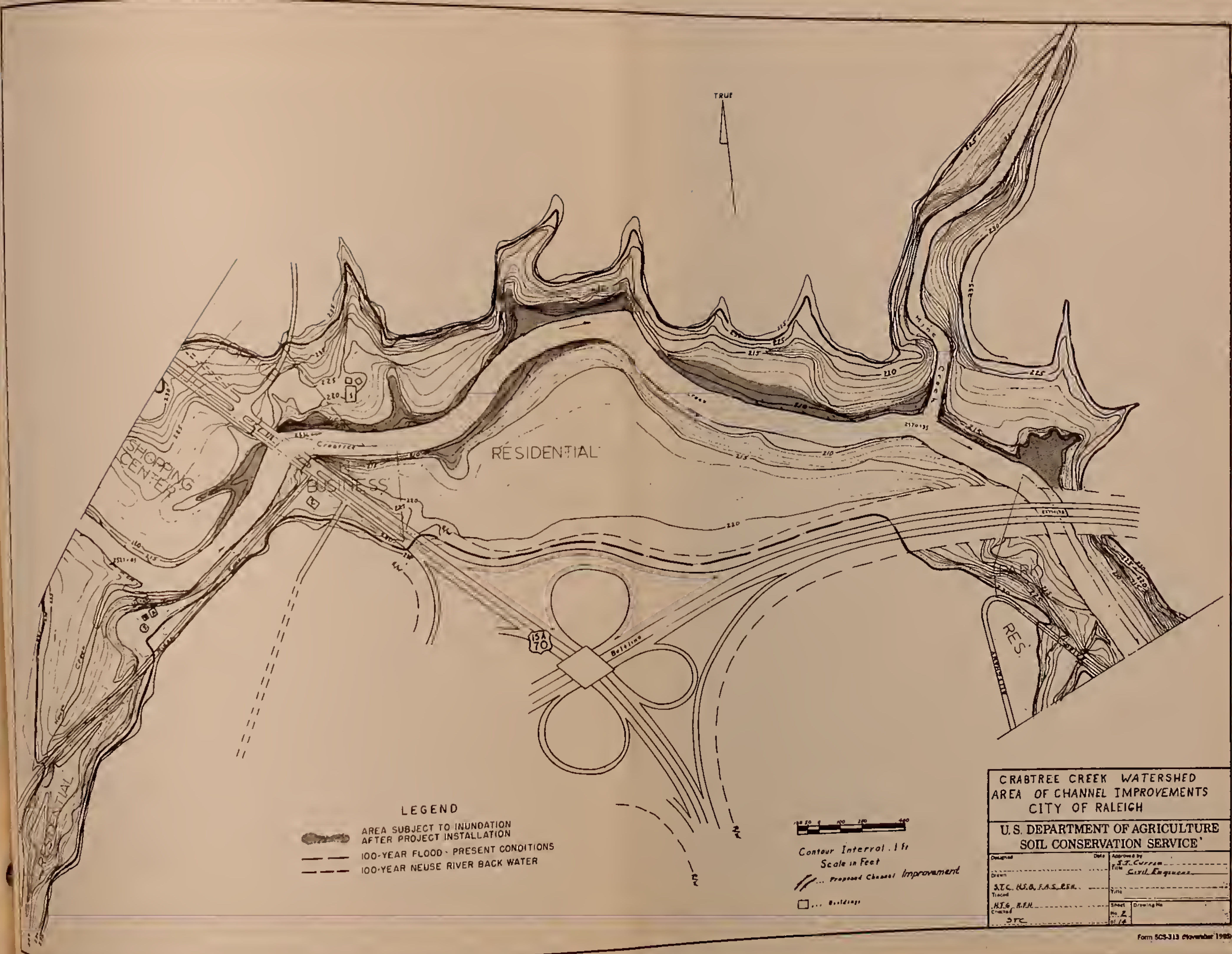
.... Buildings

CRABTREE CREEK WATERSHED
AREA OF CHANNEL IMPROVEMENTS
CITY OF RALEIGH

U.S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed — Date	Approved by S. T. CURRIN, State Engineer
Drawn S.T.C., H.S.B., F.A.S., A.E.K.	
Traced H.T.B., A.E.K.	
Checked STC	Sheet No. 1 of 1 sheets — Drawing No.

Form SCS-316 (November 1955)



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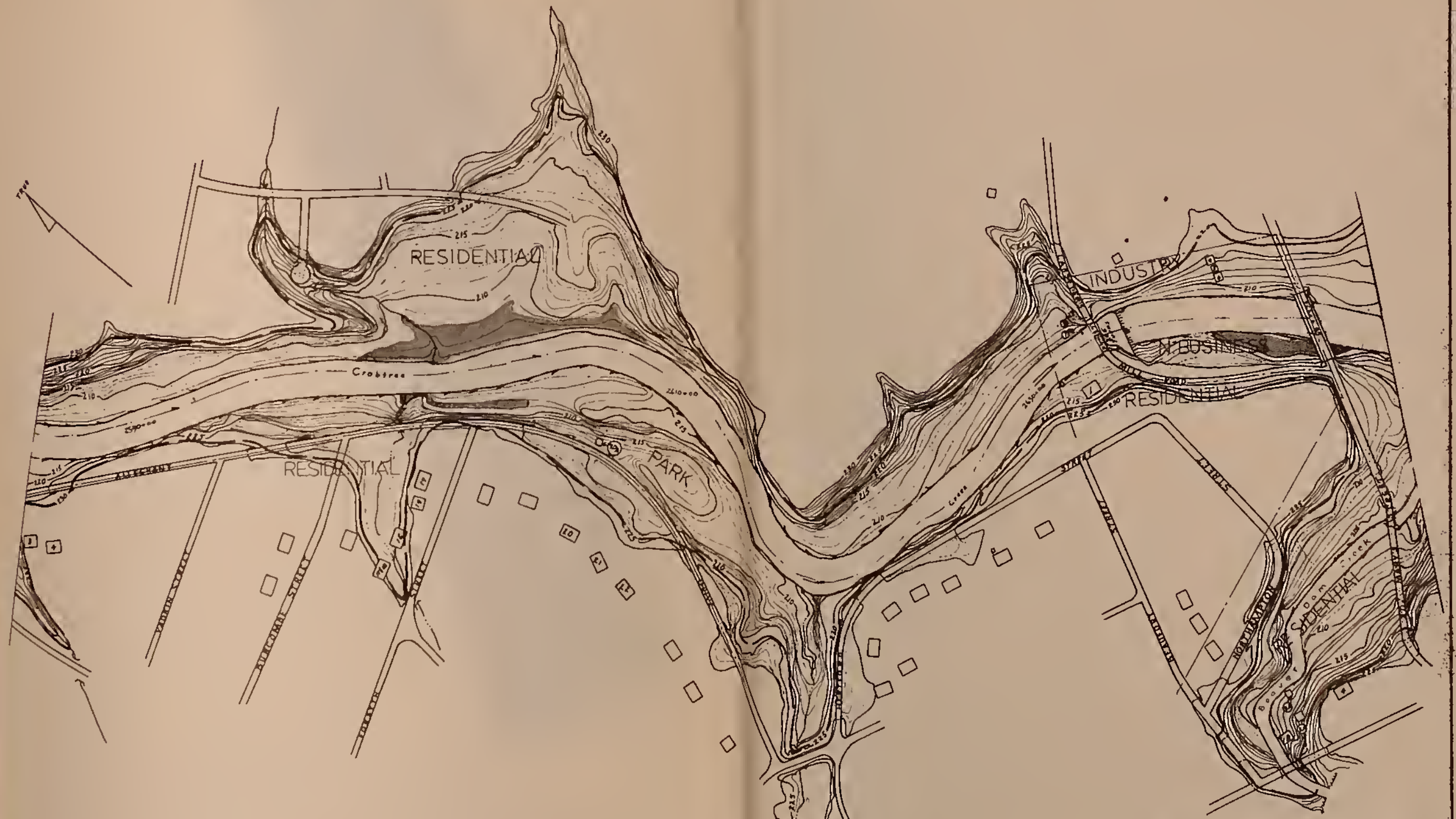


LEGEND

AREA SUBJECT TO INUNDATION AFTER PROJECT INSTALLATION

100-YEAR FLOOD - PRESENT CONDITIONS

100-YEAR NEUSE RIVER BACK WATER

Contour Interval : 1 Ft.

Scale in Feet

...Proposed Channel Improvement

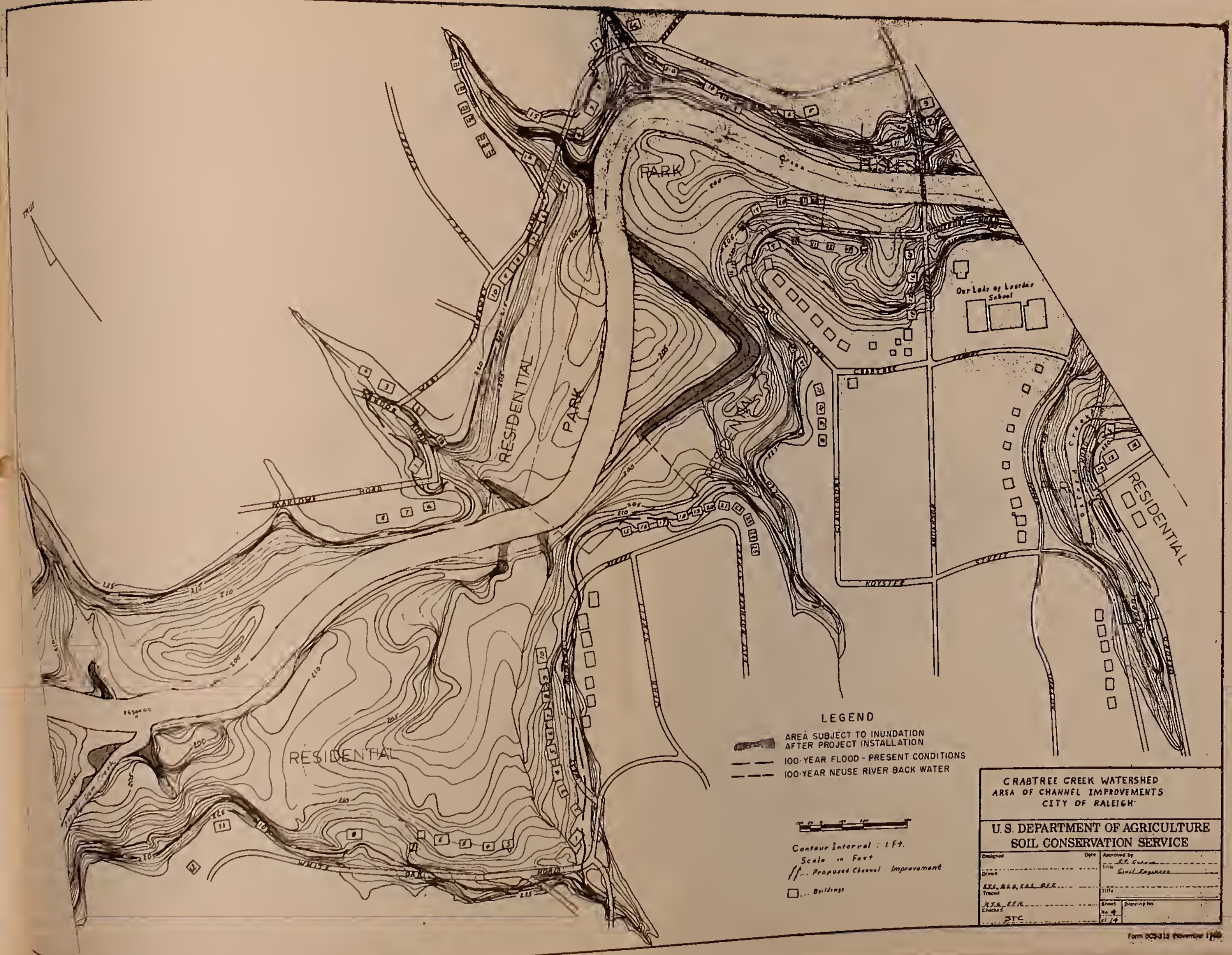
...Buildings

CRABTREE CREEK WATERSHED
AREA OF CHANNEL IMPROVEMENTS
CITY OF RALEIGH

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	Date	Approved by
Drawn		Title
Traced		Title
Checked		Sheet No. 1 of 14 sheets
		Drawing No.

Form SCS-313 (November 1965)

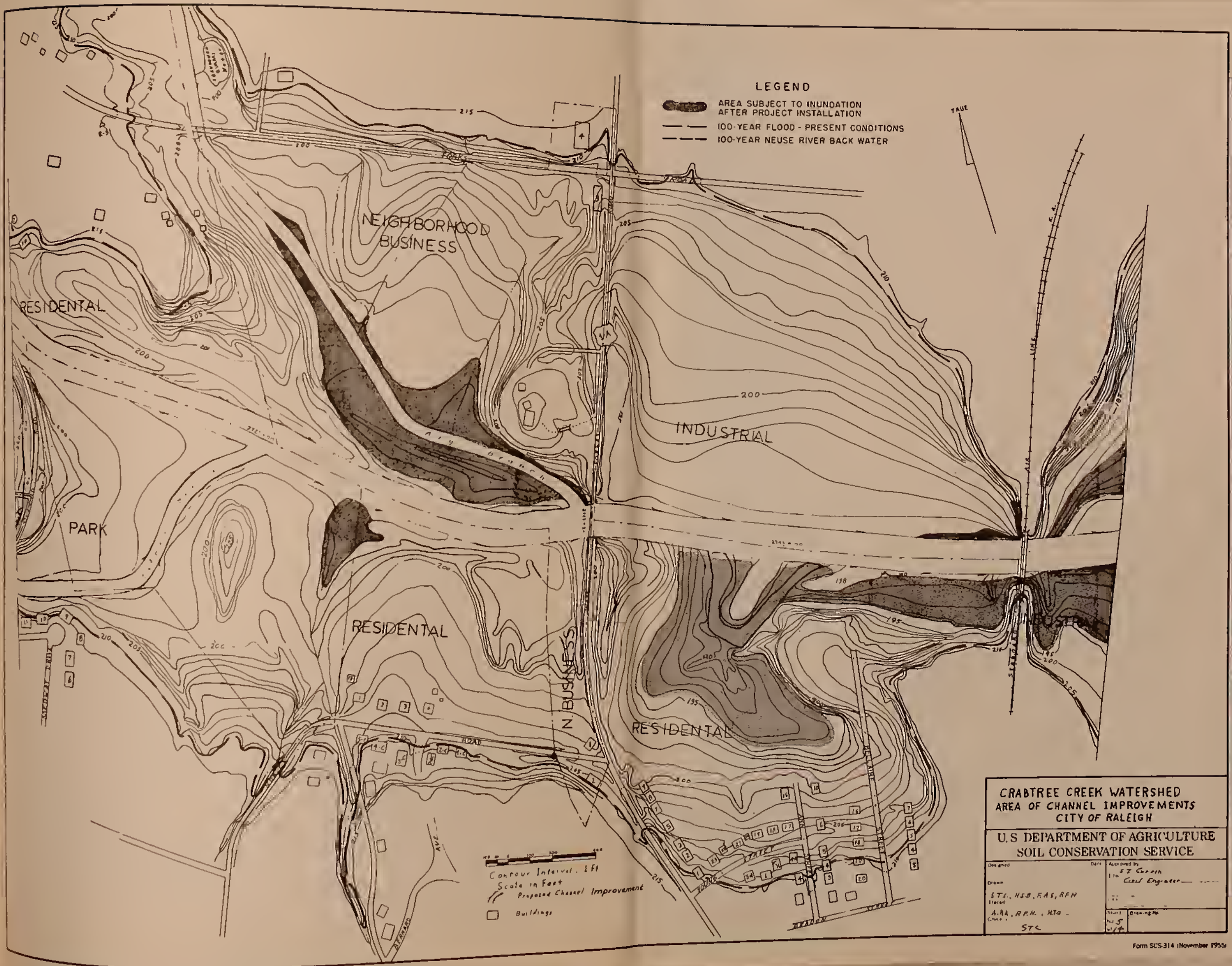


CRABTREE CREEK WATERSHED
AREA OF CHANNEL IMPROVEMENTS
CITY OF RALEIGH

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed / Date	Approved by: K.F. Greene
Drawn	Title: Civil Engineer
K.T.S., W.E.B., E.R.L., W.E.K. Traced	Title:
K.T.S., C.E.H. Checked	Sheet No. 4 of 14
STC	Drawing No.

Form SCS-312 November 1965



CRABTREE CREEK WATERSHED
AREA OF CHANNEL IMPROVEMENTS
CITY OF RALEIGH

U.S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed — Date
Approved by S T Cowin, Chief Engineer
Drawn: S.T.C., H.S.B., E.A.S., R.F.H.
Traced
Checked: A.R.A., R.F.H., H.T.G., S.T.C.
Sheet No. 5 of 11
Drawing No.

Form SCS-314 (November 1955)

LEGEND

AREA SUBJECT TO INUNDATION AFTER PROJECT INSTALLATION

100-YEAR FLOOD - PRESENT CONDITIONS

100-YEAR NEUSE RIVER BACK WATER

SHOPPING CENTER

INDUSTRIAL

INDUSTRIAL

INDUSTRIAL

RESIDENTIAL

Raleigh Farmers Market

Colonial Stores Warehouse

Pigeon House Creek

Norfolk Southern

Contour Interval : 1 Ft.

Scale in Feet

... Proposed Channel Improvement

... Buildings

... Retaining Wall

sheet 7

CRABTREE CREEK WATERSHED
AREA OF CHANNEL IMPROVEMENTS
CITY OF RALEIGH

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed — Date

Drawn

Traced

Checked SFC

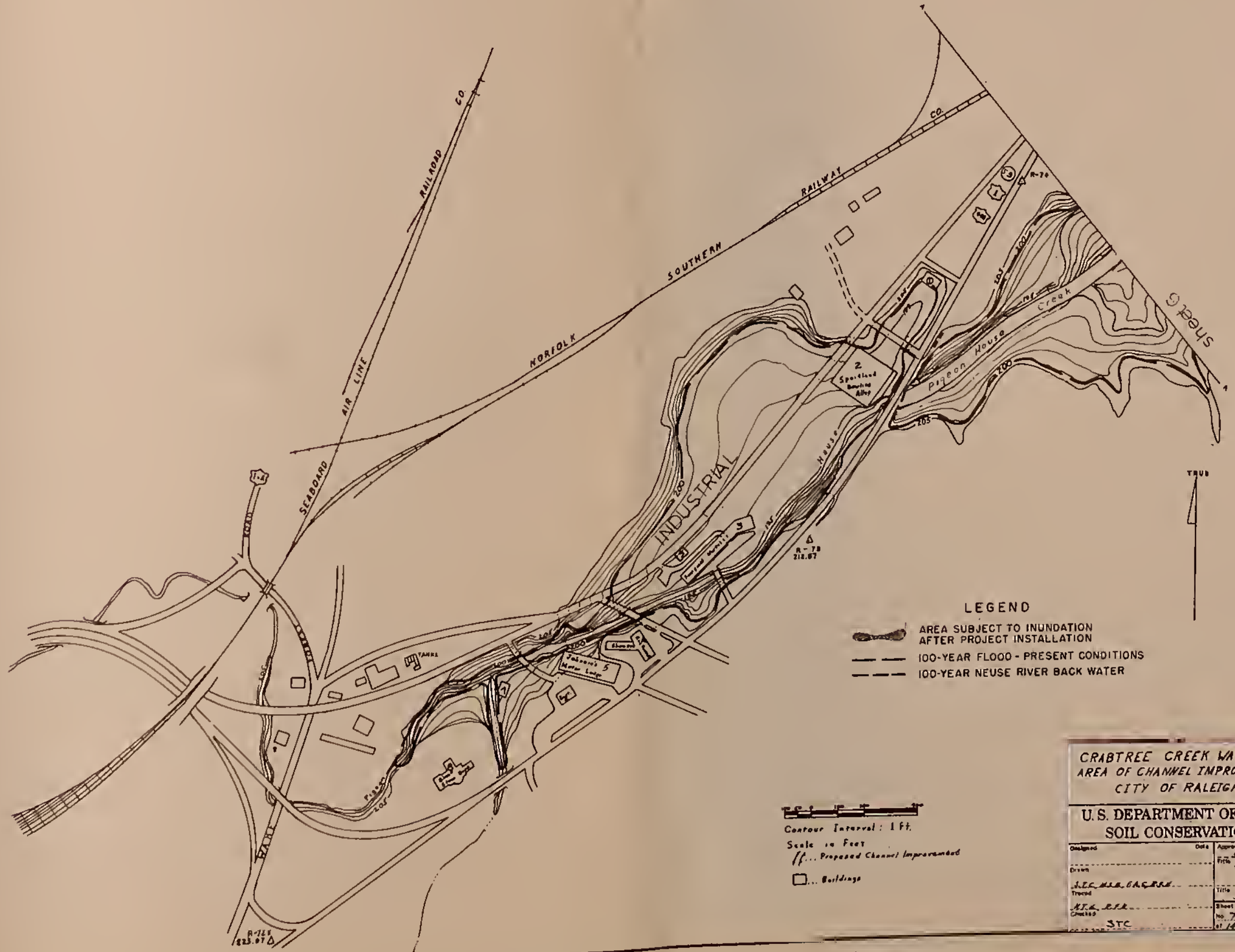
Approved by J.T. Cuscio
Title Civil Engineer

Title

Sheet No. 6 of 14

Drawing No.

Form SCS-313 (November 1966)



LEGEND

- AREA SUBJECT TO INUNDATION AFTER PROJECT INSTALLATION
- 100-YEAR FLOOD - PRESENT CONDITIONS
- 100-YEAR NEUSE RIVER BACK WATER

Contour Interval : 1 Ft.
Scale in Feet
... Proposed Channel Improvement
... Buildings

CRABTREE CREEK WATERSHED
AREA OF CHANNEL IMPROVEMENTS
CITY OF RALEIGH

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	Date	Approved by
Drawn		Title
Traced		Title
Checked STC		Sheet no. 7 of 14

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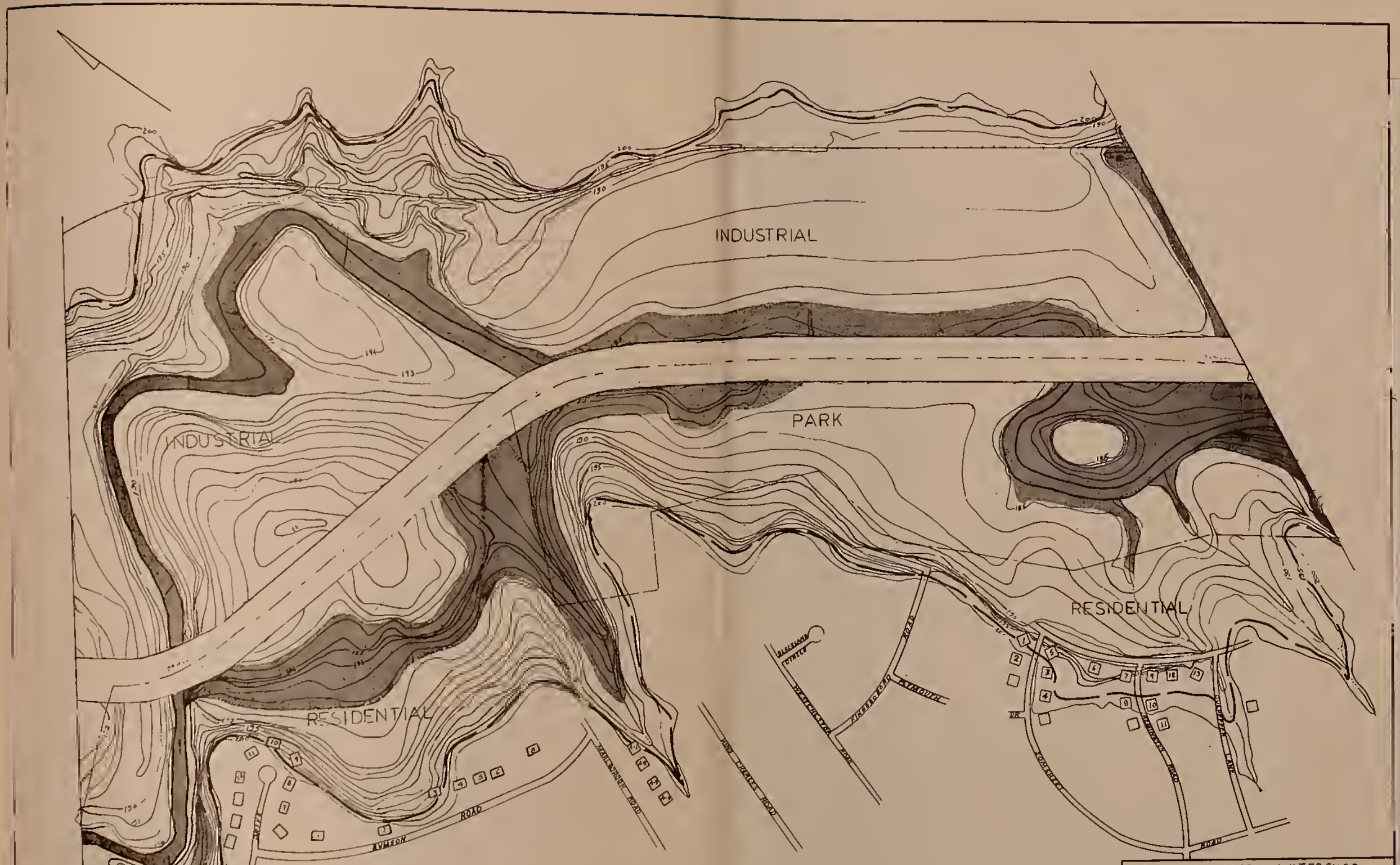


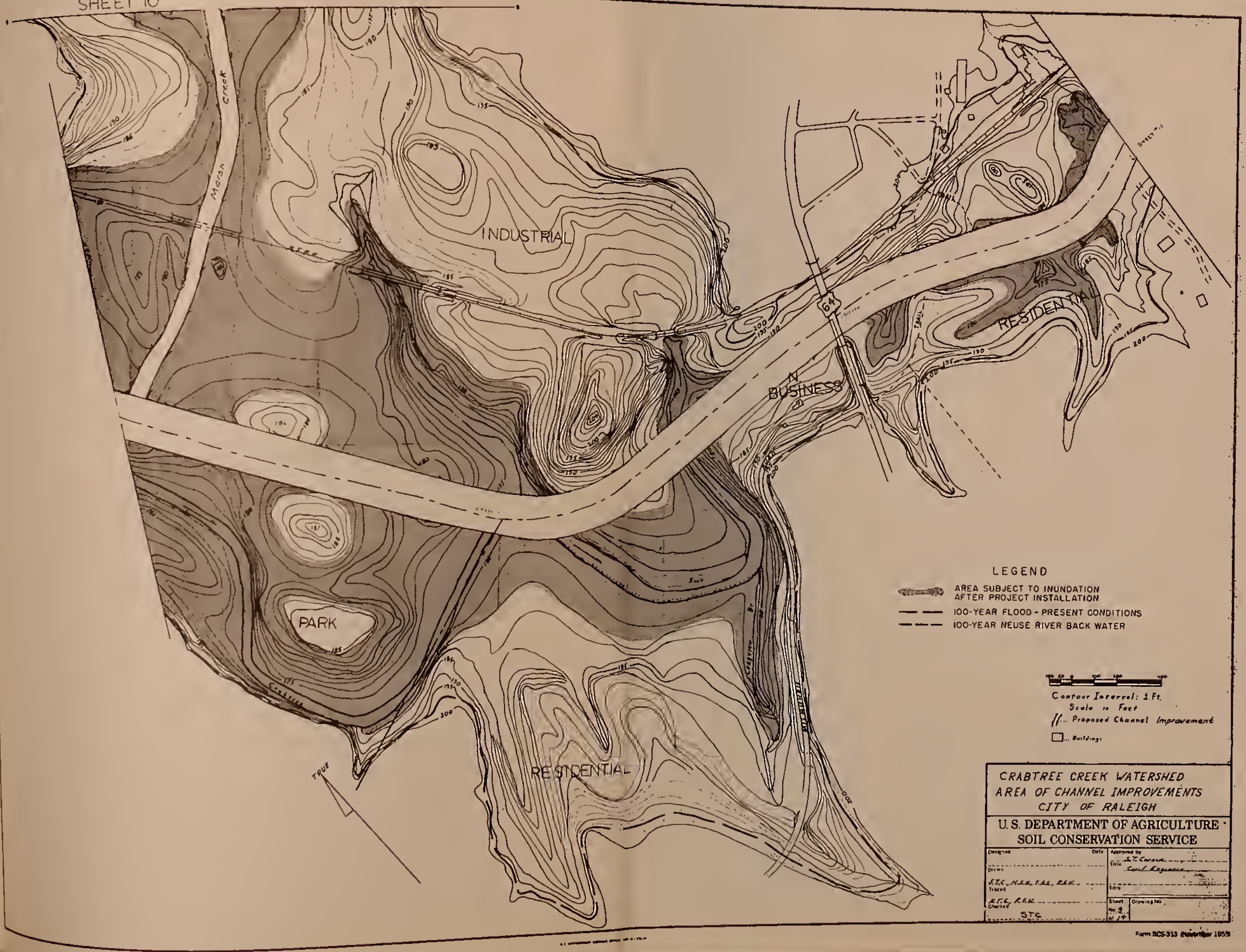
CRABTREE CREEK WATERSHED
AREA OF CHANNEL IMPROVEMENTS
CITY OF RALEIGH

U.S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	Date	Approved by
Drawn: S.T.C., H.S.B., E.A.S.		S.T. Curtis, Soil Engineer
Traced: H.T.G., A.A.B.		
Checked: STC		Sheet No. 1 of 1 — Drawing No.

Form SCS-314 (November 1955)

SHEET 10



LEGEND

AREA SUBJECT TO INUNDATION AFTER PROJECT INSTALLATION

100-YEAR FLOOD - PRESENT CONDITIONS

100-YEAR NEUSE RIVER BACK WATER

Contour Interval: 1 Ft.
Scale in Feet

Proposed Channel Improvement

Buildings

CRABTREE CREEK WATERSHED
AREA OF CHANNEL IMPROVEMENTS
CITY OF RALEIGH

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed — Date	Approved by A. T. Corson
Drawn	Title Chief, Engineering
S.T.C., H.S.H., P.A.S., R.R.H. Traced	Title
H.F.H., R.R.H. Checked STC	Sheet No. 9 of 14 — Drawing No.

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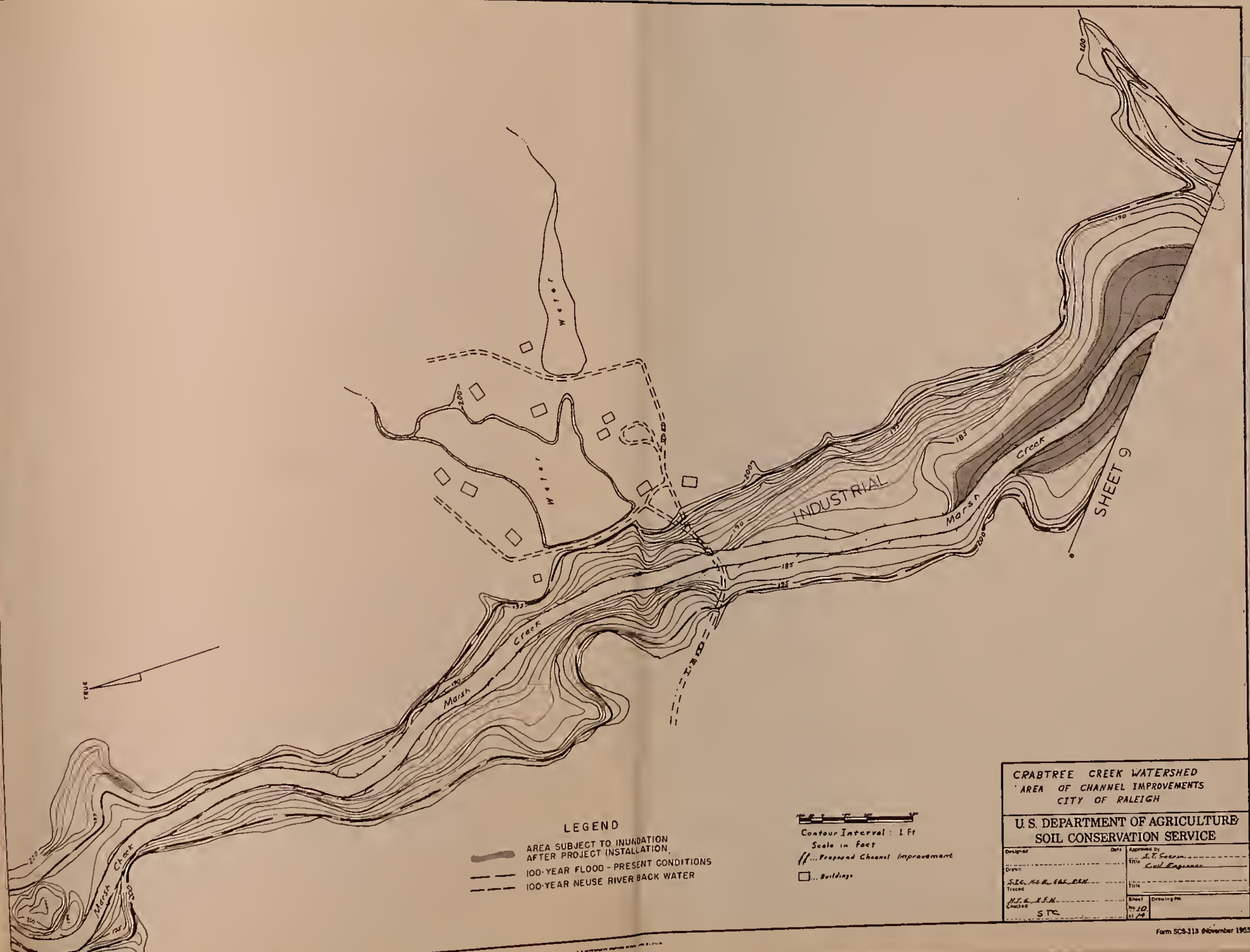

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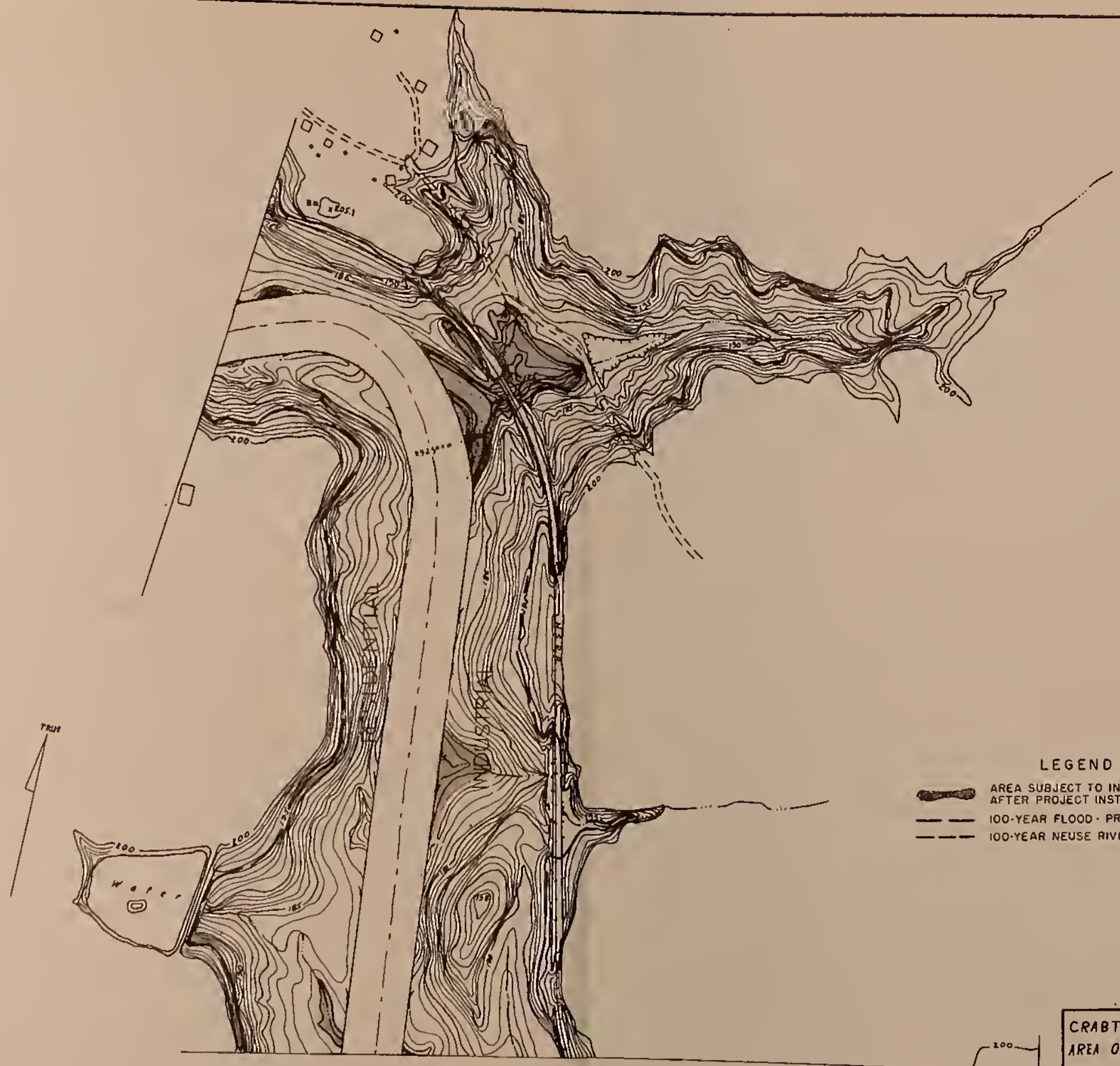


CRABTREE CREEK WATERSHED
AREA OF CHANNEL IMPROVEMENTS
CITY OF RALEIGH

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	Date	Approved by S.T. Cowin
Drawn R.S.R.		Title Soil Engineer
Traced R.S.R.		Title
Checked STC		Sheet No. 11 of 19 — Drawing No.

Form SCS-313 (November 1965)

LEGEND

AREA SUBJECT TO INUNDATION AFTER PROJECT INSTALLATION

100-YEAR FLOOD - PRESENT CONDITIONS

100-YEAR NEUSE RIVER BACK WATER

Contour Interval : 1 Ft

Scale in Feet

ff... Proposed Channel Improvement

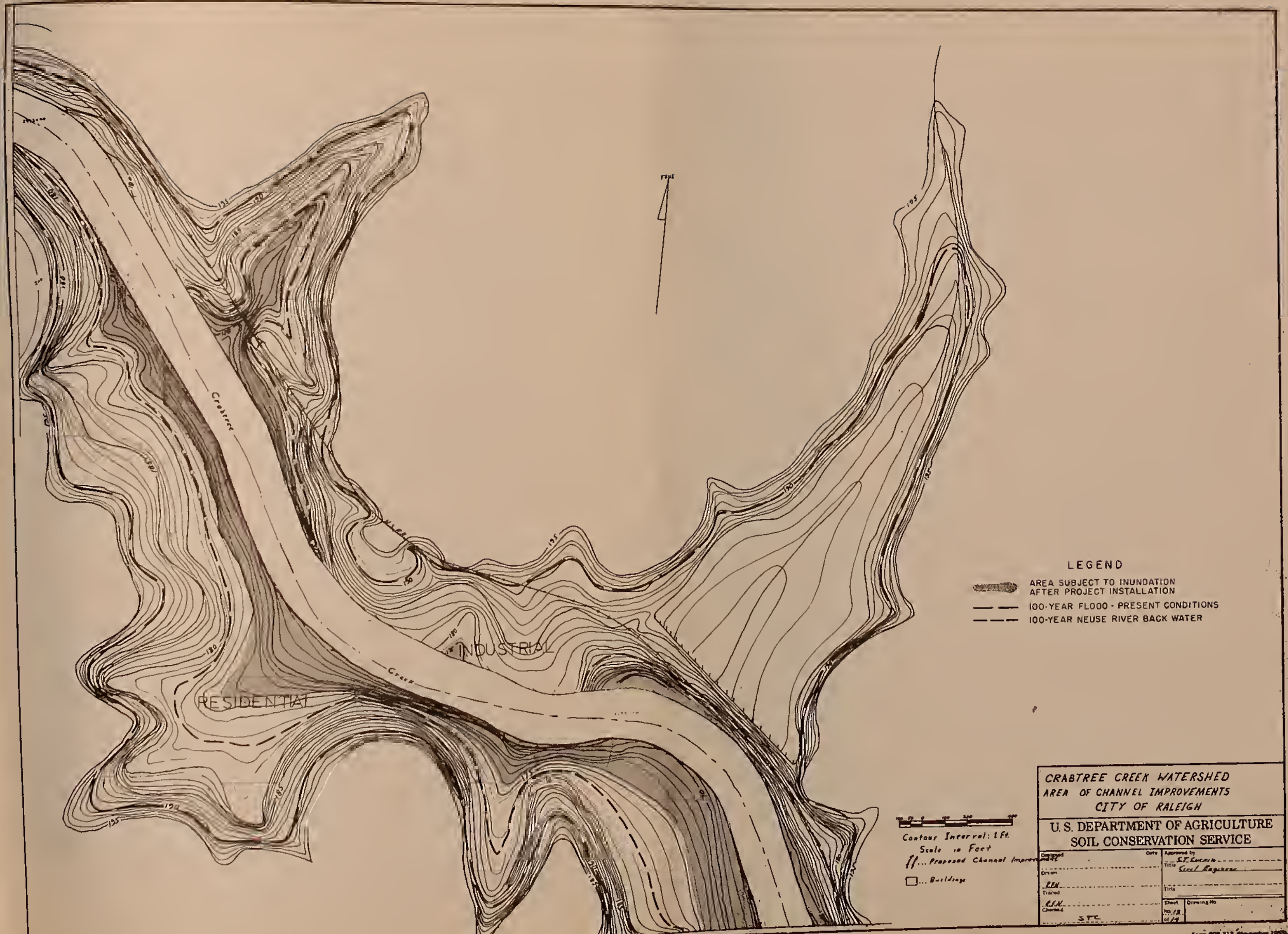
□... Buildings

CRABTREE CREEK WATERSHED
AREA OF CHANNEL IMPROVEMENTS
CITY OF RALEIGH

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	Date	Approved by S.T. Cecil
		Title Civil Engineer
Drawn R.F.H.		Title
Traced R.F.H.		Sheet No. 12 of 14
Checked STC		Drawing No.

Form SCS-313 (November 1953)



CRABTREE CREEK WATERSHED
AREA OF CHANNEL IMPROVEMENTS
CITY OF RALEIGH

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed — Date	Approved by K.F. Cowan
Drawn R.F.H.	Title Civil Engineer
Traced	Title
Checked R.F.H.	Sheet No. 18 of 19 — Drawing No.
S.T.C.	

Form SCS-313 (November 1955)

INDUSTRIAL

RESIDENTIAL

Carolina Lake

Crabtree Creek

Neuse River

X B.M. 187

TRUE

LEGEND

AREA SUBJECT TO INUNDATION AFTER PROJECT INSTALLATION

100-YEAR FLOOD - PRESENT CONDITIONS

100-YEAR NEUSE RIVER BACK WATER

Contour Interval: 1 Ft.
Scale in Feet
... Proposed Channel Improvement
... Buildings

CRABTREE CREEK WATERSHED
AREA OF CHANNEL IMPROVEMENTS
CITY OF RALEIGH

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Approved by: C.F. Curtis
Title: Civil Engineer

Form SCS-313 (November 1958)